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Volume 22, No. 6

EDITORIALS

Engineering Implications of War

REGARDLESS of the extent to which the Americas may or may not ultimately become involved in Europe, Asia, and Africa's present wars, it seems certain that we will share substantially in the "blood, sweat, and tears" incidental to the destruction involved and subsequent reconstruction.

Precautionary defense preparations, sabotage, the disturbance of normal trade, the unsettling of populations, our humanitarian interests, and the interference of these factors with our solution of major problems of peace time economy—all these and more combine to assure that some of the cost of these wars will fall upon us.

If we can face this probability honestly, seriously, firmly, without hysteria, we can begin to see some of its implications.

It implies emphasis on engineering, and the results engineers can produce in increased work effectiveness, conservation of manpower and resources; and increased flexibility of production to meet the rapidly changing demands of war, peace, and reconstruction. American engineering will find increased opportunity for service and have, relatively, less manpower with which to render that service. We will all work more, accomplish more, and when our contribution to the cost of war is paid, have less in a material way. But we can come through this period as stronger men and better engineers.

Consider the broader implication that engineers might materially influence the manner in which our part of the cost of war will be paid; how much in relatively harmless sweat, and how much in blood and tears.

Strong people, strong character, strong democracies are not built on a soft life. Hardships may be either constructive or destructive. They can be sufficient to exercise and strengthen the moral fiber, or they can overtax, undermine, and destroy it.

The tragedy of war is not that it destroys much of the means and opportunity for soft living, but that its hardships destroy people unnecessarily and build character only incidentally. Strength can be developed by hardships other than those of physical combat.

It is the self-imposed constructive hardship of hard work and of driving ourselves to diligent forethought and action, which can build strength in democracy and provide the means of bringing a quicker end to war and its destructive hardships; which can influence the cost of war and reconstruction in sweat, and in blood and tears.

In this, as workers, thinkers, planners, organizers; as men of disciplined originality and considered action; as providers of many of the tools of war and peace, engineers should be leaders.

Farmers as Building Craftsmen

IN THE current discussion of ways and means of initiating nation-wide farm building improvement, D. H. Malcom has contributed some thoughts on the building problems of business farmers. Without minimizing the importance of giving subsistence farmers all the help they are capable of utilizing, he raises a legitimate question as to the building problems of the approximately 35 per cent of the total farmers in the United States, farming the best 20 per cent of its land area, producing the largest volume of marketed farm products and farm income, and representing 70 per cent of farm building valuation.

These business farmers do have building problems. And from the standpoint of their smaller numbers; their responsiveness; their leadership in their respective communities; the value of their land, production, and building investment; their economic and social importance as producers and consumers—they are the farmers who can be most easily and quickly helped with their building problems, with most immediate and greatest advantage to the nation as a whole. Moreover, help to them may, in the long run, be expected to contribute financially, technically, and in farm leadership, to ways and means of helping subsistence farmers.

Mr. Malcom further points out that the way in which business farmers can be helped differs from the way in which subsistence farmers can be helped, particularly in the matter of who should do farm building work. Proposals for encouraging farmers to do more of their own carpenter, mason, and other building trades work have often failed to make this distinction entirely clear.

Specialization in productive work and exchange of resulting goods and services has developed and survived through the ages entirely on its merits as a means by which individuals can apply and improve their productive capacities along lines for which they are best fitted; and by trading part or all of their output for that of other specialists, enjoy more material welfare than they could possibly achieve as self-sufficient personal producers of all they consume.

The degree and kind of specialization which can be practiced profitably, and the specific matters in which it may be more desirable to be self-sufficient, are individual, personal problems. A logical answer for any individual depends on his preferences, abilities, capacities, industry, and versatility; on the available resources to or through which his productive efforts might be applied; and on the demand for products or services for exchange, of which he could be an effective specialized producer.

Consequently, generalizations to the effect that farmers as a group should become either more specialized or more self-sufficient, are inaccurate.

Many farmers who are not fully and effectively occupied in production of farm commodities for sale, and who could not readily be helped to become so occupied, might be helped to become more self-sufficient in the construction, alteration, and maintenance of buildings to meet their requirements. It would represent a step of progress for them, improving their use of time, increasing their labor income in terms of real values, and making their limited cash income go further.

Farmers can afford to buy, rather than provide their own tools of production, building materials, and construction services, only as and to the extent that they can and do use the time and energy saved, and the production aids thus obtained, to increase their effectiveness as producers of marketable commodities.

On the other hand, business farmers can afford to divert their attention from their main, highly specialized job of production for market, and of protecting their investment, only as an avocation, recreation, a non-conflicting secondary interest, a matter of emergency repair to keep their production work moving on schedule, or a means of providing themselves with certain aids to farm production and comfortable farm living which may not be readily available commercially. Their time will generally be worth more to them as managers (Continued on page 214)

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Physical Reactions of Soil on Plow Disks

By E. D. Gordon

MEMBER A.S.A.E.

INFORMATION concerning the characteristic soil reactions on plow disks is limited, since most of such investigational work covers only the field operation of disk harrows. Stirniman[1]* has reported on the draft of disk harrows of various types. A qualitative analysis of the soil reaction on disk harrows and offset disk harrows was developed by McKibben[2]. His laboratory studies were supplemented by observations under field conditions. Measurement of the soil forces acting on disks was undertaken by Clyde[3] under field conditions subjected to some measure of control. In this study the effect of disk angle, angle of inclination, disk diameter, and moisture content of the soil were observed. From the standpoint of engineering design and operation, Sjogren[4] has set forth important features of the offset disk harrow, and from the same standpoint Ingersoll[5] has given a fairly complete picture of the standard disk plow.

The study of soil reactions on plow disks reported in this paper was made in the soil bins of the U.S.D.A. farm machinery laboratory at Auburn, Alabama. The tests were made under controlled conditions and represent a departure from what may be considered strictly field conditions. The data shown for the various points discussed are averages of three or more runs and in some cases represent averages of observations made under two or more soil conditions. This report deals altogether with observations in the Decatur clay and Davidson loam soil bins. The mechanical analyses of these two soils are given in Table 1.

TABLE 1.

Soil type	Mechanical analysis		
	Sand, per cent	Silt, per cent	Clay, per cent
Davidson loam	72.8	3.4	23.8
Decatur clay	28.1	31.3	40.6

The Davidson loam plot has a high sand content with a moderate amount of clay. The Decatur soil does not dry out as quickly as the Davidson loam and generally exerts greater resistance on the plow disk than the Davidson loam.

The bin soil plots, soil fitting and dynamometer equipment, and methods of test at the farm machinery laboratory have been previously described in detail[6].

Fig. 1 shows the complete hookup of the dynamometer car and the test car ready for a test run. Fig. 2 shows the plow disk test unit in place in the test car. When this test unit is coupled to the dynamometer, the blade is then supported in a framework which imparts the reaction of the soil on the disk to six hydraulic cells. These cells, in turn, actuate Bourdon tube type elements to which pens are attached. From this record of pressures, the soil reactions on the disk are broken down into three directional components: the force required to pull the disk forward, and referred to herein as the draft; the vertical reaction either upward or downward on the disk; and the side thrust on the disk. The figures given for the vertical component of soil reaction do not include the weight of the disk.

Definition of Terms. Most of the tests herein discussed were made with disks having a nominal diameter of 26 in. This is a comparatively large disk and was chosen because it is a size common to both vertical-disk-plow and standard-disk-plow units[7].

Disk angle, a term common to both the standard disk plow and the vertical disk plow, is defined as the angle, viewed from the top of the disk facing the direction of travel, between the plane of the disk edge and the line of travel of the implement.

The *angle of inclination* is the angle, viewed from the side of the disk, between the plane of the disk edge and a vertical line. Fig. 3 shows the manner in which these angles are designated.

Revised paper presented before the Power and Machinery Division of the American Society of Agricultural Engineers at the fall meeting of the Society at Chicago, December 6, 1939.

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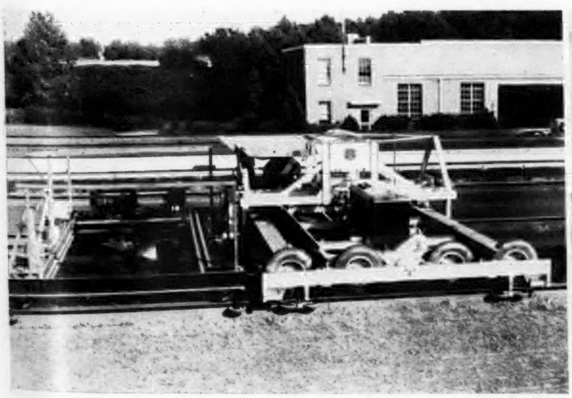
*Superscript figures indicate references cited at the end of this paper.



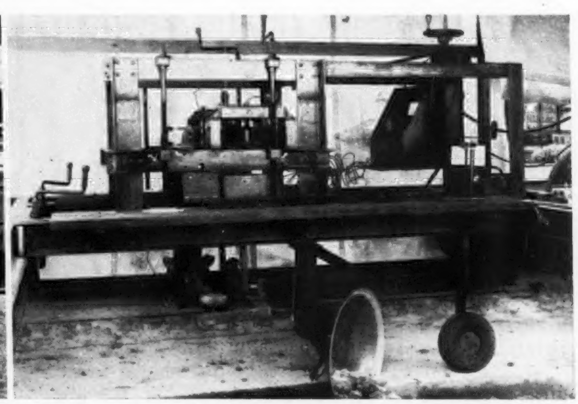


Fig. 1 (Left) Power car and test car coupled up for a test run. Fig. 2 (Right) Plow disk test unit

In Tables 2 to 11 inclusive, the column headed "Thrust perpendicular to plane of disk" has been computed by combining the draft and side thrust vectors of soil reaction on the disk and determining from this combination of forces the portion which is perpendicular to the plane of the disk. In cases where the disk is inclined, all three vectors of soil reaction on the disk have been combined and that portion perpendicular to the plane of the disk determined. These figures indicate the trends of soil reaction on disks for various angles, speeds, concavities, etc. For purposes of design, these figures would necessarily have to be multiplied by a larger factor.

TABLE 2. SOIL REACTION ON DISKS IN RELATION TO SPEED

(Disk diameter, 26 in; radius of curvature, 22.4 in)

Speed, mph	Draft, lb	Vertical reaction upward, lb	Side thrust, lb	Thrust, perpendicular to plane of disk, lb	SOIL CONDITIONS Range of depth, in	Apparent sp gr	Moisture content, per cent
1.60	382	69	139	322			
2.98	421	41	161	373	0 - 2	1.48	14.3
4.64	548	16	229	510	0 - 6	1.53	15.9
6.30	618	8*	278	598			
Soil, Decatur clay; Width of cut, 9 in		Depth of cut, 6 in; Disk angle, 45 deg			Inclination angle, 20 deg		
					SOIL CONDITIONS Range of depth, in	Apparent sp gr	Moisture content, per cent
2.26	163	3*	26	127			
3.70	223	15*	48	193			
4.75	289	56*	118	290	0 - 2	1.53	7.24
6.03	367	101*	162	384	0 - 6	1.65	9.10
Soil, Davidson loam; Width of cut, 7 in		Depth of cut, 6 in; Disk angle, 46 deg			Inclination angle, 18 deg		

*Indicates reaction is downward on disk.

Unless otherwise specified, the tests described in the following paragraphs were made at speeds of 3.5 to 3.7 mph.

Soil Reactions on Disk in Relation to Speed. Fig. 4 and Table 2 show the effect of speed of operation in the Decatur clay and Davidson loam. These tests were made with the disk inclined as a standard disk plow blade. The slope of the two draft curves indicates that the rate of increase is nearly the same in the two soils. Even though the disk blade cuts 2 in wider in the Decatur clay, the draft requirements per square inch of furrow cross section are greater in the Decatur clay than in the Davidson loam. An inspection of the curves plotted for draft shows that the increase in draft with speed is not uniform, but increases at a slightly accelerated rate with the speed.

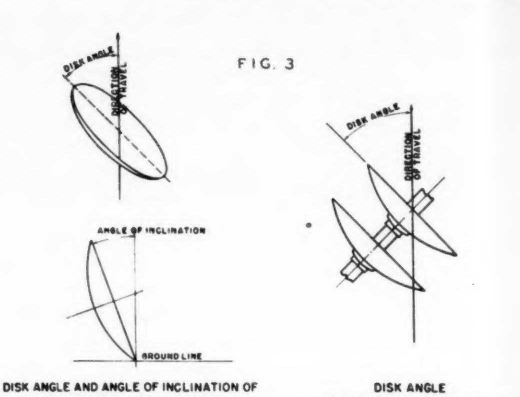
TABLE 3. SOIL REACTION ON THE DISK IN RELATION TO DISK ANGLE (Davidson Loam)

Disk angle, deg	SOIL REACTIONS Draft, lb	Vertical component, lb	Side thrust, lb	Thrust, perpendicular to plane of disk, lb	SOIL CONDITIONS Range of depth, in	Apparent sp gr	Moisture content, per cent
		Depth of cut, 4 in					
36	142	10	103	175			
41	130	14*	105	167	0 - 2	1.41-1.66	6.59-11.98
46	130	11*	90	155	0 - 4	1.56-1.68	7.53-11.53
51	136	25*	83	150			
		Depth of cut, 6 in					
36	199	80	24	175			
41	192	53	68	189	0 - 2	1.66	6.34
46	198	3*	88	201	0 - 6	1.74	8.46
51	214	32*	107	218			
		Depth of cut, 8 in					
36	341	136	57	309			
41	273	18	133	293	0 - 2	1.68	8.47
46	306	14	182	343	0 - 8	1.81	10.16
51	328	14	162	332			

Width of cut, 7 in Radius of curvature, 22.4 in
Disk diam., 26 in Speed, 2.2 mph Angle of inclination, 0 deg
*Indicates reaction is downward on the disk.

It appears, from that portion of the table showing the thrust perpendicular to the plane of the disk, that the increase in soil reaction on the disk, as the speed is increased, is caused by the soil being thrown a greater distance forward and to the right at the higher speeds.

FIG. 3



DISK ANGLE AND ANGLE OF INCLINATION OF STANDARD DISK PLOW BLADE

DISK ANGLE OF THE VERTICAL DISK PLOW

The curves showing the vertical reaction on the disk indicates that the disk tends to penetrate better at the higher speeds. This has been observed to be true under a variety of conditions in these soils.

Soil Reactions on Disks in Relation to Disk Angle and Angle of Inclination. Fig. 5 was plotted from that portion of Tables 3 and 4 in which the data for the 6-in depth of cut was tabulated. The draft on the disk attains a minimum for a disk angle of about 45 deg. The tendency in both soils is for the draft to increase rather sharply for disk angle settings above 45 deg. The depth of concavity for the disk data shown in Tables 3 and 4 was 4 1/16 in. For small disk angles, where there is increased area of contact between the furrow wall and the convex side of the disk, there is a tendency for the draft to be increased.

TABLE 4. SOIL REACTIONS IN RELATION TO DISK ANGLE (Decatur Clay)

Disk angle, deg	SOIL REACTIONS Draft, lb	Vertical component upward, lb	Side thrust, lb	Thrust, perpendicular to plane of disk, lb	SOIL CONDITIONS Range of depth, in	Apparent sp gr	Moisture content, per cent
36	348	134	237	421			
41	318	73	261	411	0 - 2	1.42	12.97
46	307	59	244	388	0 - 6	1.50	14.88
51	378	21	266	445			

Width of cut, 7 in Speed, 2.2 mph Radius of curvature, 22.4 in
Depth of cut, 6 in Disk diam., 26 in

As the disk angle is increased, the disk will penetrate better. The data for Fig. 5 was obtained with the disk in a vertical position. The same tendency for the disk to penetrate better as the disk angle was increased can be observed in the data in Tables 5 and 6. In this data the disk was tested at a 15-deg angle of inclination.

In Table 7 and Fig. 6 the effect of angle of inclination is shown. There is not only a marked increase in draft with increase in the angle of inclination, but there is also a tendency for reduced penetration of the disk at the greater angle of inclination. The data in Tables 3 to 7 indicate that for improved penetration in hard ground, the angle of inclination should be reduced and the disk angle increased. Increasing the disk angle in a standard disk plow unit by shifting the main frame with respect to the line of travel also reduces the width of cut of the individual blades. In hard, tightly packed soil this adjustment may prove necessary.

Disk Concavity. In Table 8 and Fig. 7 the measurements of soil reactions on disks of various concavities are

TABLE 5. SOIL REACTION ON DISKS IN RELATION TO DISK ANGLE (Decatur Clay)

Disk angle, deg	SOIL REACTIONS Draft, lb	Vertical reaction upward, lb	Side thrust, lb	Thrust, perpendicular to plane of disk, lb	SOIL CONDITIONS Range of depth, in	Apparent sp gr	Moisture content, per cent
Width of cut, 7 in			Depth of cut, 6 in				
40	513	117	203	475	0 - 2	1.74	14.90
45	449	94	163	394	0 - 6	1.67	17.58
50	497	50	145	403			
Width of cut, 9 in			Depth of cut, 6 in				
40	515	120	224	489	0 - 2	1.65	12.80
45	471	75	203	441	0 - 6	1.66	16.45
50	492	36	167	411			

Inclination angle, 15 deg Radius of concavity, 22,4 in
Disk diameter, 26 in

shown. The disk with a concavity of 4 15/16 in (distance measured from the disk center to the plane of the disk edge) represents an extreme in this respect. It has not proved to be generally practical to use a disk having this much cup. However, it has been included for purposes of comparison. It will be seen from Fig. 7 that the draft tends

TABLE 6. SOIL REACTION ON DISKS IN RELATION TO DISK ANGLE (Davidson Loam)

Disk angle, deg	SOIL REACTIONS Draft, lb	Vertical reaction upward, lb	Side thrust, lb	Thrust, perpendicular to plane of disk, lb	SOIL CONDITIONS Range of depth, in	Apparent sp gr	Moisture content, per cent
Depth of cut, 6 in			Width of cut, 7 in				
40	216	115	25	145	0 - 2	1.53	11.51
45	170	15*	60	161	0 - 6	1.69	10.69
50	225	33*	81	208			
Depth of cut, 8 in			Width of cut, 7 in				
40	190	33	41	158	0 - 2	1.52	8.62
45	156	19*	59	152	0 - 8	1.56	9.32
50	179	34*	70	172			
Depth of cut, 6 in			Width of cut, 9 in				
40	273	131	22	175	0 - 2	1.53	11.51
45	258	21*	146	282	0 - 6	1.69	10.69
50	261	75*	130	277			

Inclination angle, 15 deg Radius of concavity, 22.4 in
Disk diameter, 26 in

*Indicates reaction is downward on disk.

to increase with the concavity. Obviously the deeper the cup or concavity of the disk, the smaller the radius of concavity. In the heavier soils, as represented by the Decatur clay in this study, the disk having the greatest concavity is reacted upon by a considerable upward thrust as compared with disks of moderate concavity. However, this tendency was not so marked in the Davidson loam.

Disk Diameter. From an operating viewpoint there are obvious advantages to the use of larger disks. From the standpoint of soil reactions, Tables 9 and 10 reveal that the

TABLE 7. SOIL REACTION ON THE DISK IN RELATION TO ANGLE OF INCLINATION

Angle of inclination, deg	SOIL REACTIONS Draft, lb	Vertical reaction, lb	Side thrust, lb	Thrust, perpendicular to plane of disk, lb	SOIL CONDITIONS Range of depth, in	Apparent sp gr	Moisture content, per cent
					Soil type, Davidson loam		
15	327	35	118	295	0 - 2	1.53-1.74	6.38-11.51
20	389	72	92	295	0 - 6	1.66-1.80	8.03-10.68
25	419	135	61	253			
					Soil type, Decatur clay		
15	479	81	174	424			
20	533	92	143	418	0 - 2	1.62	13.73
25	592	159	97	374	0 - 6	1.57	15.45

Disk diameter, 26 in Depth of cut, 6 in Radius of curvature,
Disk angle, 45 deg Width of cut, 9 in 22.4 in

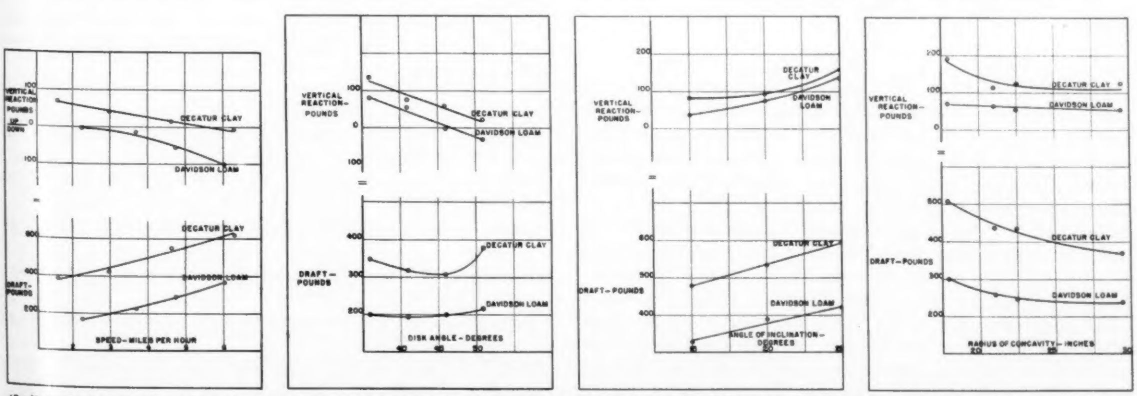
smaller disks require slightly more draft. They require more weight to hold them to the same depth of cut than do the larger disks. Furthermore, the smaller disk has a greater side thrust on it with the result that the thrust perpendicular to the plane of the disk is also greater. The bottom section of Table 9 gives a summary of tests made with the disks inclined at an angle of 19 deg. With this setting, the draft is lower for the smaller disk and the upward thrust on the disk is also less, a reversal of these reactions on the disk in a vertical position. In the Decatur clay, Table 10, the differences in draft and upward thrust are not so great; however, with no inclination of the disk

TABLE 8. SOIL REACTION IN RELATION TO DISK CONCAVITY

DISK DATA Diameter, in	Depth of cup, in	Radius of curvature, in	SOIL REACTIONS Draft, lb	Vertical component, lb	Side thrust, lb	Thrust perpendicular to plane of disk, lb
24 15/16	4 15/16	18.2	300	70	63	257
25 13/16	4 7/16	21.0	259	63	83	242
25 23/32	4 1/16	22.4	245	53	92	238
25 7/8	3	29.4	239	53	176	293
24 15/16	4 15/16	18.2	508	190	190	494
25 13/16	4 7/16	21.0	436	113	186	440
25 23/32	4 1/16	22.4	435	122	259	491
25 7/8	3	29.4	369	125	266	449

SOIL CONDITIONS Range of depth, in	Apparent sp gr	Moisture content, per cent
Soil type, Davidson loam		
0 - 2	1.63	13.15
0 - 6	1.59	15.49
Soil type, Decatur clay		
0 - 2	1.83	9.51
0 - 6	1.77	9.91

Width of cut, 7 in Depth of cut, 6 in Disk angle, 45 deg Inclination angle, 0 deg Speed, 3.6 mph



(Left to Right) Draft and vertical reaction on 26-in disks in relation to speed (Fig. 4), in relation to disk angle (Fig. 5), in relation to angle of inclination (Fig. 6), and in relation to concavity (Fig. 7)

the larger disk will penetrate the soil better than the smaller disk.

A Comparison of Notched and Plain-Edge Disks. The reactions of soils on disks having a notched edge, in comparison with those on plain-edged disks, are summarized in Table 11. The notched-edged disk had slightly less draft than the plain in the vertical position. However, in the Decatur clay soil with a disk inclination of 20 deg, the draft of the plain-edge disk was lower and soil penetration was accomplished with less weight on the disks. With the disks held vertically, the upward thrust was slightly less on the notched disk.

TABLE 9. SOIL REACTION ON DISKS IN RELATION TO DISK DIAMETER

(1) Disk diameter, 19 11/16 in; radius of curvature, 23.25 in
(2) Disk diameter, 25 23/32 in; radius of curvature, 22.4 in
Disk angle, 45 deg Soil type, Davidson loam

	SOIL REACTIONS				SOIL CONDITIONS		
Nominal disk diameter, in	Draft, lb	Vertical reaction upward, lb	Side thrust, lb	Thrust, perpendicular to plane of disk, lb	Range of depth, in	Apparent sp gr	Moisture content, per cent
Width of cut, 7 in Depth of cut, 4.6 in Angle of inclination, 0 deg							
(1) 20	203	60	138	241	0 - 2	1.71	7.45
(2) 26	164	27	127	206	0 - 6	1.72	9.25
Width of cut, 9 in Depth of cut, 6.0 in Angle of inclination, 0 deg							
(1) 20	377	82	244	439			
(2) 26	344	68	210	392			
Width of cut, 7 in Depth of cut, 6.0 in Angle of inclination, 0 deg							
(1) 20	341	50	250	418	0 - 2	1.91	8.08
(2) 26	328	26	218	386	0 - 6	1.86	10.18
Width of cut, 9 in Depth of cut, 6.0 in Angle of inclination, 19 deg							
(1) 20	413	55	110	331	0 - 2	1.82	7.79
(2) 26	464	93	61	324	0 - 6	1.74	8.67

TABLE 10. SOIL REACTION ON DISKS IN RELATION TO DISK DIAMETER

(1) Disk diameter, 19 11/16 in; radius of curvature, 23.25 in
(2) Disk diameter, 25 23/32 in; radius of curvature, 22.4 in
Disk angle, 45 deg Soil type, Decatur clay

	SOIL REACTIONS						
Nominal disk diameter, in	Draft, lb	Vertical reaction lb	Side thrust, lb	Thrust, perpendicular to plane of disk, lb	Angle of inclination, deg	Width of cut, in	Depth of cut, in
(1) 20	308	97	185	348	0	9	6.0
(2) 26	304	73	174	338	0	9	6.0
(1) 20	183	79	123	217	0	7	4.6
(2) 26	171	77	91	185	0	7	4.6

SOIL CONDITIONS

Range of depth, in	Apparent sp gr	Moisture content, per cent
0 - 2	1.56	11.49
0 - 6	1.50	12.74

Bearing Friction. The observations discussed in this paper were made with the disk mounted on a spindle which rotated in an anti-friction bearing. The same results would most probably have been obtained with the disk spindle rotating in a well-constructed and adjusted plain bearing. What differences might arise would most likely not be detected. If the disk were measurably restricted in its tendency to rotate, there would be some differences in the soil reaction on the disk. A few observations were made in a heavy clay soil in which the disk was locked so that it could not turn. The draft was greater than was observed where the disk was free to turn, and the vertical reaction on the disk indicated that less weight was required for soil penetration with the disk locked. The side thrust on the disk was lower.

TABLE 11. SOIL REACTIONS ON NOTCHED AND PLAIN-EDGE DISKS

	SOIL REACTIONS				SOIL CONDITIONS		
Disk edge	Draft, lb	Vertical reaction upward, lb	Side thrust, lb	Thrust, perpendicular to plane of disk, lb	Range of depth, in	Apparent sp gr	Moisture content, per cent
Width of cut, 7 in Depth of cut, 6 in Angle of inclination, 0 deg					Soil type, Davidson loam		
Plain	277	48	130	289	0 - 2	1.87	9.21
notched	253	49	130	271	0 - 6	1.79	10.01
Width of cut, 7 in Depth of cut, 6 in Angle of inclination, 0 deg					Soil type, Decatur clay		
Plain	278	83	138	294	0 - 2	1.63	15.54
notched	266	73	125	277	0 - 6	1.56	15.76
Width of cut, 9 in Depth of cut, 6 in Angle of inclination, 20 deg					Soil type, Decatur clay		
Plain	323	11	146	308	0 - 2	1.51	18.18
notched	348	38	130	304	0 - 6	1.50	17.59

Disk diameter, 26 in Radius of concavity, 22.4 in
Notched disk, 12 notches Disk angle, 45 deg

SUMMARY

Pulling plow disks through a sandy loam soil and a fairly heavy clay soil has shown that soil type and soil conditions produce the most pronounced differences in soil reactions on the disks.

The factor of speed has been shown to exert a definite influence on soil reactions on disks. The draft of a disk in a sandy loam soil was increased 67 per cent with an increase in speed from 2½ to 5 mph.

At a disk angle setting of around 45 deg, the draft on the disk was at a minimum. The upward thrust on the disk was reduced as the disk angle was increased, which tends to improve soil penetration.

As the angle of inclination of a disk was increased, the upward thrust on the disk was increased, tending to cut down on depth of penetration.

The draft of disks and the upward thrust of the soil increased with increase in concavity.

A slight difference in draft in favor of the large disk was observed. Also, due to reduced upward thrust, the larger disk would tend to penetrate better. When the disks were inclined from the vertical position, the draft and penetration factors were reversed in favor of the smaller disk.

A comparison of notched and plain-edge disks showed slightly significant differences in draft and ability to penetrate into the soil. However, when the disks were tipped back, the notched disk had the greater upward soil thrust.

It must be kept in mind that the observations made in this study were obtained under controlled laboratory conditions. In field conditions where vegetative material, crop residues, stones, etc., are encountered, disk blade operation would be substantially altered, especially as to magnitude of soil reactions.

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Acid-Resistant Concrete Coatings

By J. R. Spraul

WORK reported in this paper was undertaken to find suitable coatings for use on concrete stave silos to resist the disintegrating action of acids generated in ensilage. Almost all the materials used in this study were furnished by nationally known manufacturers, and, for the most part, are regularly offered for sale. This paper attempts to give a comparative picture of the value of each of these materials under the action of weak acid, abrasion, and water absorption.

EXPERIMENTAL

Each coating was subjected to two different tests. First, an accelerated acid flow test[1] subjected the coating to acid action and abrasion. The test of Miller, Rogers, and Manson was altered by using a stronger (0.2 N) acetic acid, and the maximum period of the test was reduced to ten days.

The accelerated acid flow test gives a comparative picture of the acid-resisting qualities of each coating. The production of sand, gravel, and cement loosened from the coated bar by brushing was taken as evidence of disintegration. Although the loosened material obtained by the brushing was dried and weighed, the table gives only the number of days the coating withstood the test before erosion appeared.

This test also brings out several other important properties of a coating. It must have good coverage or the brushing will wear out thin parts of the coating and permit disintegration to start. The coating must also form a good bond with the concrete to prevent peeling or pitting, both of which permit disintegration to begin.

The second test involved drying a 2-in cube of concrete, entirely coated, in an electric oven at 75 to 85 C (degrees Centigrade) for a period of 24 hr. This temperature was used because ensilage often approaches it. The cubes were then weighed, placed in beakers, and allowed to remain under tap water at room temperature for another 24 hr. The cubes were removed, weighed again, and the percentage of absorption was calculated from the two weights. This water absorption test, while contributing less to the estimation of the value of a coating than the acid flow test, is a good measure of porosity. It was hoped that this test would give a method of predicting whether a coating would permit ensilage to stick to the silo wall, but in field tests, which are described later, no general rule has been determined.

All the concrete bars and cubes used in this investigation were made by the "dry tamped" method. The proportions of the ingredients by weight when dry were: gravel, 3.84; coarse sand, 2.42; fine sand, 1.00; cement, 1.52. Enough water was then added to give a water-cement ratio of 3.1 gal per sack of cement. These proportions make seven staves, 12½ in wide and weighing about 79 lb each, per sack of cement. The concrete was cured in a steam chamber at about 75 C for 24 hr and then given a 7-days curing in air at room temperature.

Abridged adaptation, for publication in AGRICULTURAL ENGINEERING, of material submitted to the faculty of the graduate school of University of Indiana, in partial fulfillment of the requirements for the Ph. D. degree. Author: Research fellow in chemistry, University of Indiana.

[1]Miller, D. G., Rogers, C. F., and Manson, P. W. Laboratory tests of concrete and mortars exposed to weak acids. Agr. Engr. 20:11 (November 1939).

RESULTS

From the 91 different coatings tested, the table includes those found to resist the acid flow test for more than 10 days, and a few coatings now in general use, for comparison. I believe that, unless the coating allows the adhesion of ensilage, each day of the acid flow test will approximate one year of actual use in a silo. Whether or not ensilage will adhere can be determined only by actual use.

Some of the coatings tested were placed on silos last summer. These silos were inspected recently after one year of use and notes on the results of this inspection are included in the following table:

TABLE OF RESULTS

Coating number	Description and cost of coating	Description of coating after one year's use	Acid flow test. Time in days of first evidence of disintegration	Water absorption. Weight gained by 2-in coated cube in tap water for 24 hr, per cent
Uncoated concrete			1	6.2
WAXES (All the waxes were applied by melting the wax, brushing it on the concrete, and driving it in with a burner, leaving only a thin film on the surface)				
1	Paraffin (melting point 49 C). Cost, 2-3 cents per lb	This coating peels and checks slightly on a silo. This could be overcome if a silo were gone over with a blow torch every year	6	4.5
2	Paraffin plus a microcrystalline petroleum hydrocarbon wax (melting point of wax, 140-145 F). Equal parts. Cost of wax, 5⅝ cents per lb	The addition of the higher melting-point, less brittle wax to the paraffin improves the coating. Still good after one year	8	No test
3	Paraffin plus butyl methacrylate polymer (1:1) fused together. Cost of polymer, 75 cents per lb		Greater than 10	3.1
4	Paraffin plus stearin pitch (1:1). Cost of pitch, 4 cents per lb	Some peeling of the coating near top of silo	Greater than 10	0.24
5	Paraffin plus stearin pitch (3:1)		Greater than 10	2.7
ASPHALT COATINGS (Two coats applied in all cases, with 24 hr between coats)				
6	Grade A liquid asphalt paint. Cost, 16 cents per gal	Ensilage sticks and takes off some of the coating	Greater than 10	3.2
7	Heavy-duty black asphalt coating. Cost, $2.10 per gal	Excellent	Greater than 10	5.7
RUBBER BASE PAINTS				
8	An acid-resisting paint with a rubber derivative as a base, and containing graphite. Two coats were applied, with 4 hr between coats. Cost, $3.80 per gal	Excellent	Greater than 10	8.3
9	Latex water emulsion. Applied in same manner as No. 8		Greater than 10	3.7
10	A rubber-base paint. Two coats were applied with 24 hr between coats. First coat thinned with 15 per cent xylol. Cost, $2.50 per gal		Greater than 10	3.9

RESIN VARNISHES				
11	50 g of cumarone resin, 15 cu cm of fish oil, and 40 g of xylol. Stirred until homogeneous. One coat	Previous experience has shown that this coating resists disintegration for 2-3 yr	3	3.1
12	Same as No. 11, except that 10 g of 125 centipoise chlorinated rubber was dissolved in the xylol before mixing with the resin and fish oil. One coat		Greater than 10	4.6
13	A phenol modified oxidizing type alkyd applied as a 50 per cent solution in mineral spirits plus No. 11 in equal parts. One coat. Cost of alkyd solution, 13¼ cents per lb	Ensilage sticks at joints of staves	Greater than 10	4.7
14	One coat of a toluol solution of a polystyrene resin, sold as a primer. (Cost, 40 cents per gal) followed in 4 hr by a coat of a regular polystyrene resin varnish		Greater than 10	4.5
15	An inert base paint containing chlorinated rubber. Two coats applied with first coat thinned considerably with a special thinner. Cost $3.25 per gal; thinner, $.60 per gal	Good	Greater than 10	2.7
16	A vinylite lacquer. The first coat thinned with 15 per cent of a special thinner. The second unthinned coat was applied after 24 hr. Cost of lacquer, $3.10 per gal; thinner, $0.45 per gal		Greater than 10	0.31
17	50 g of a chlorinated diphenyl resin, 15 cu cm of linseed oil, 10 g of 125 centipoise chlorinated rubber dissolved in 40 g of toluene. One coat. Cost of resin, 27 cents per lb		Greater than 10	0.7
18	50 g of a terpene phenolic resin (melting point 275-285F), 15 cu cm of tung oil dissolved in 40 g of xylol. One coat. Cost of resin, 14½ cents per lb		Greater than 10	3.4
19	50 g of butyl methacrylate polymer, 15 cu cm of linseed oil dissolved in 40 g of xylol. One coat. Cost of resin, $0.75 per lb		Greater than 10	0.5
20	Oxidizing type alkyd resin - chlorinated rubber formula. 40 g of the resin were dissolved in 40 g of toluene, and 0.5 g of 4 per cent cobalt naphthenate drier were added. Ten g of 10 centipoise chlorinated rubber were dissolved in another 40 g portion of toluene and the two solutions were mixed. Two coats applied. Cost of resin, 12½ cents per lb. Cost of rubber, 35 cents per lb	Excellent	Greater than 10	0.2
21	Oxidizing type alkyd (No. 20) melted and added to equal weight of No. 11. Cobalt and lead naphthenate driers added. One coat	Ensilage sticks around the joints between the staves	Greater than 10	4.7
MISCELLANEOUS				
22	A coal tar derivative coating. One (cold) coat applied. Cost, $0.75 per gal		Greater than 10	3.7
23	Stearin pitch. This coating was applied in the same manner as the waxes		Greater than 10	7.7
24	Equal parts of stearin pitch and stearic acid fused together and applied by the usual wax method		Greater than 10	3.5

RESULTS OF OTHER TESTS

1 A series of coatings made up of one-half pound of a resin and two pounds of 125 centipoise chlorinated rubber dissolved in one gallon of xylol were placed on silos last summer but not tested in the laboratory. The resins used were cumarone, a liquid phenolformaldehyde, and vinsol. After one year's service these coatings appear to be in excellent condition.

2 Other waxes such as cetyl acetamide, carnauba, ceresine, and ozokerite did not give results as satisfactory as those for the waxes reported in the accompanying table. In the laboratory, beeswax and candelilla wax gave results similar to paraffin.

3 The drying oils — soy bean, linseed, cottonseed, tung, and perilla — gave little protection to the concrete. The addition of lead and cobalt naphthenate driers to the oils increased their resistance slightly. The oils, especially tung oil, did give extra resistance as primer coatings for a resin varnish.

4 The addition of flue dust, bentonite, infusorial earth, animal charcoal, sulfur, wood charcoal, and basic calcium lignin sulfonate to the cumar varnish (No. 11) did not increase the resistance.

5 Natural resins, such as amberol, paranol, and ester gum, made into a varnish with linseed oil and xylol were not as satisfactory as the average synthetic resin.

6 Stearin pitch was successfully dissolved in a number of coal tar solvents and drying oils, but these solutions failed as coatings, because they possessed a brittleness that made them flake off easily when the concrete was brushed.

CONCLUSIONS

1 The most important consideration with waxes is their ease of application. Failures among the waxes are mostly due to high melting points and difficulty in applying the wax before it solidifies. Rapid solidification leads to brittleness and peeling, permitting disintegration to start. Good results were obtained with a mixture of paraffin and a softer, less brittle wax such as the microcrystalline petroleum hydrocarbons.

2 Asphalt coatings in general are very resistant to weak acids, but they often cause ensilage to adhere.

3 Most rubber-base paints have high acid resistance. The difficulty encountered in their use is the maintenance of a good bond between coating and concrete.

4 A chemically resistant resin varnish containing chlorinated rubber usually gave good results. The resin penetrates the concrete and forms a good bond, while the chlorinated rubber at the same time gives toughness and extra resistance to the coating.

AUTHOR'S NOTE: The work reported in this paper was carried on at Indiana University under a fellowship granted by the Concrete Silo Company, of Bloomfield, Indiana, and the author wishes to thank Mr. Walter Brassert for his cooperation in connection with the study.

Electrolytic Heater for Incubators

By S. R. Cruz

JUNIOR MEMBER A.S.A.E.

THIS paper is to report work done on the development of the electrolytic heater for incubators which was undertaken in the laboratory of the agricultural engineering department at Cornell University under the supervision of H. W. Riley.

In an ordinary small electric incubator, the heat is produced by a metallic heating element, usually made of nichrome wire connected in series with a pair of make-and-break points to a 110-v source. A fixed condenser is connected across the breaker points, which are actuated by a wafer thermostat, this in turn being sensitive to the changes of temperature inside the incubator. In this type, the temperature is inherently not constant, because the make-and-break sequence of the power supply depends upon a constantly changing temperature. Thus, in a forced-draft incubator the temperature varies above and below 100 F (degrees Fahrenheit), or in a natural-draft incubator above and below 102 F, while the power input has alternately maximum and zero values.

In the incubator with an electrolytic heating element (Figs. 1 and 2) monel metal electrodes are immersed in a bath of sodium hydroxide and surrounded by glass sleeves. The incubator temperature remains constant at 100 F, within ½ deg, even though a radically changing room temperature may require decided variation in power input. In practice, the incubator room temperature is kept fairly constant at 75 or 80 F, and in this case the incubator temperature will show no measurable variation and the power input will remain steady.

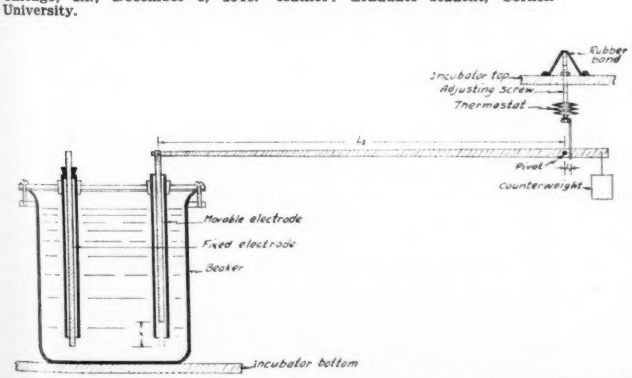
This sensitive and continuous control of the power input, which enables it to follow closely the variation of room temperature, is made possible by the use of the glass sleeves. If there were no glass sleeves, the movable electrode would have to be withdrawn almost entirely out of the solution to reduce the power input materially. However, surrounding the electrodes with one-inch glass sleeves makes possible a sharp reduction in the power input with a relatively short upward movement of the movable electrode. Using ⅜-in glass sleeves in conjunction with a high thermostat arm ratio (60 : 1) increases the sensitivity greatly.

Adaptation of a paper presented before the Rural Electric Division at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 6, 1940. Author: Graduate student, Cornell University.

Use of the small sleeves, however, introduces a serious difficulty. As soon as the movable electrode goes up into the sleeve about 2 in from its extreme downward position, it is true that the power input is reduced, from 320 to 75 watts (Fig. 3), but this reduced power now flows through a small body of liquid in the column in the sleeve below the lower end of the movable electrode, and this liquid is brought to boiling point almost immediately after the movable electrode goes up. The steam thus generated interrupts the smooth flow of the current.

This difficulty was reduced by piercing the walls of the lower end of the sleeve around the movable electrode with a row of perforations (Fig. 3). These perforations provide additional paths for the current to pass through with the result that heat generation is more widely distributed and the heat is easily dissipated by convection to the main body of the solution.

While the most important consequence of the use of the glass sleeve is the increased sensitivity of the power control, it also has several other important effects. Without the glass sleeves, the maximum power input depends on the height of the liquid in the container, especially when a much lower but broader container is used. A high liquid level gives a high maximum power input, and vice versa. The glass sleeves make the maximum power input practically independent of the height of the liquid, because the upper layers of liquid participate but slightly, if at all, in the conduction of the current. Secondly, the introduction of the glass sleeves makes it possible to maintain a uniform temperature in the electrolyte, because it is only in the bottom layer that heat is developed and this is distributed by convection. Also, the sleeves make possible the separation of the oxygen and hydrogen gases if direct current is used.



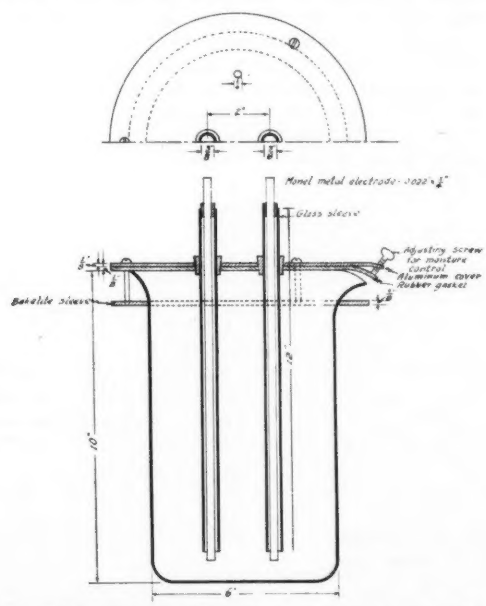


Fig. 1 (Left) Final arrangement adopted for the electrolytic heating element and thermostatic mechanism. Fig. 2 (Right) Final heater construction, showing principal dimensions of container, electrodes, and tubes

It may be that this latter characteristic will have additional value. It was found that exposure of the chick embryo during the first five days of incubation to an oxygen concentration of about 32 per cent increases hatchability and growth, and decreases early mortality. It has been found[1] that near the end of incubation, between the 18th and 20th days, the chick embryo breathes, in the air space of the egg, an atmosphere containing more carbon dioxide than oxygen (9.11 and 8.57 per cent, respectively). It is also a well-known fact that the greatest mortality of the embryos (more than 20 per cent) occurs within this period. Although many reasons and causes have been advanced for this phenomenon, I surmise that the abnormal atmosphere which the embryo breathes just prior to hatching has much to do with this high mortality. Many investigations about the effect of low oxygen concentrations (lower than the 21 per cent normal in air) on the embryo have been undertaken, but not more than three at most have been done on the effect of higher than normal oxygen concentrations on the development of the embryo. This is because of the lack of a simple but reliable source of oxygen. The electrolytic heater serves admirably as such a source. I have demonstrated that by introducing into a closed vessel the oxygen which is liberated during the operation of the electrolytic heater, the oxygen content in the vessel can be kept fairly constant at any desired level for long periods of time (Fig. 4).

The apparatus involved is cheap and easily obtainable, and, therefore, experiments on the effect of high oxygen concentrations on the chick embryo at the later stages of development can be performed with a sufficient number of eggs, with four or five replications, so that the data gathered can be treated statistically. Another important experiment which is made possible by the present heater is to find the combined effect of high temperature, relative humidity, and oxygen concentration on the growth of the embryo. Each of these three factors accelerates growth up to a certain limit.

In the ordinary electric incubator, moisture must be supplied from a separate source, usually a pan of water for small incubators, and quite complicated arrangements for large types. In the electrolytic incubator the moisture is supplied by the heater itself. Because of the relatively higher temperature of the solution, compared to that of the water pan, the moisture opening must be restricted and controlled. This is done simply by the rubber gasket and

[1]Romijn, C. and Roos, J. The air space of the hen's egg and its changes during the period of incubation. Jour. Physiol. 94:365-379. (1938).

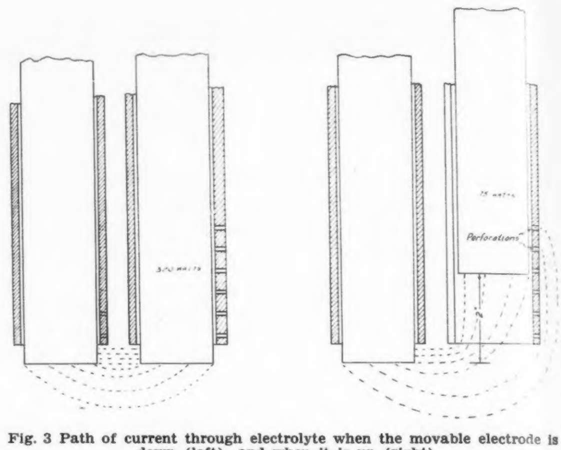
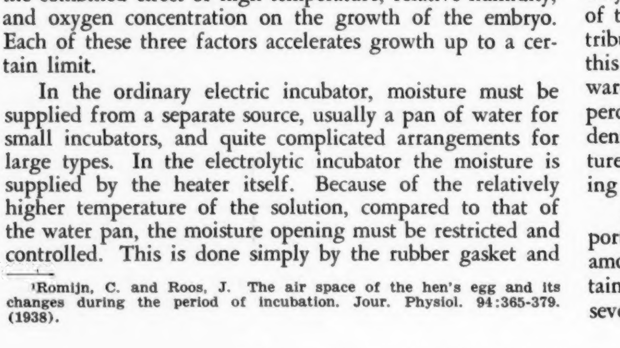


Fig. 3 Path of current through electrolyte when the movable electrode is down (left) and when it is up (right)

adjusting screw shown in Fig. 2. The relative humidity in the incubator, during the blank and actual incubation tests carried out, was kept within narrow limits (between 55 and 70 per cent) while the incubator room moisture content fluctuated widely.

During the development of the electrolytic incubator a simple but novel arrangement of air circulation was resorted to. Many patents have been granted on methods of air circulation in incubators for the express purpose of obtaining a uniform temperature without too much air velocity, because rapid air movement over the eggs is injurious to the development of the embryo. Fig. 5 shows the scheme developed for the electrolytic incubator. Air is circulated only around the bottom of the egg chamber out of range of the lowest egg tray, so that the heat can be evenly distributed in this lower layer. Then, because warm air rises, this uniform bottom temperature is distributed evenly upward with a minimum of air movement. In this manner the percentage hatchability of the eggs was improved. Incidentally, this scheme of obtaining a uniform air temperature in the incubator is almost identical with that of securing a uniform liquid temperature in the heater vessel.

Another feature of the electrolytic heater which is important, especially in rural areas, is the fact that the large amount of heat in the liquid of the heater units will maintain the incubator temperature above the danger point for several hours in case of power failure.



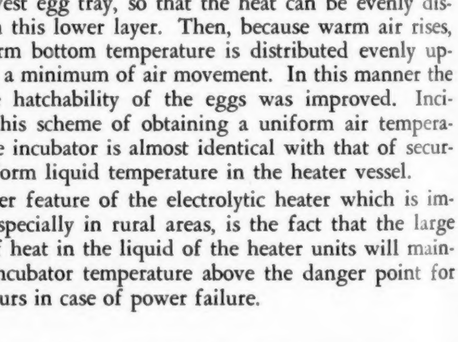


Fig. 4 (Left) Setup for oxygen concentration experiment. Fig. 5 (Right) Final arrangement for air movement and heater layout

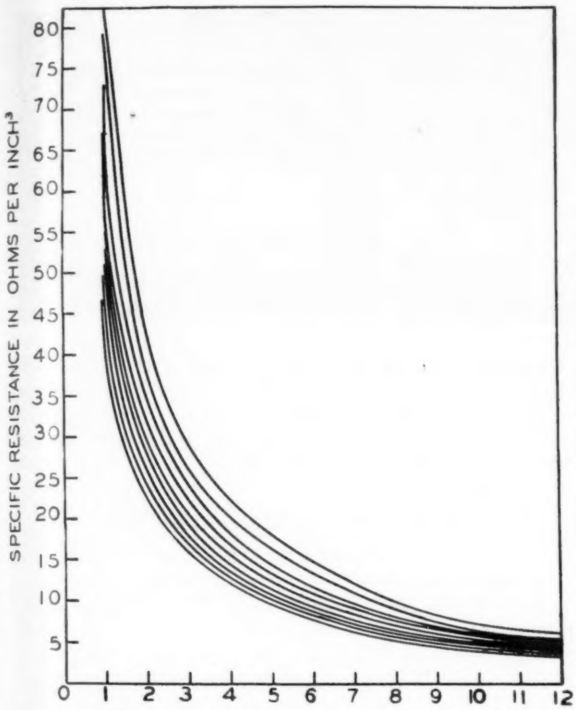


Chart 1 Variation of resistance of sodium hydroxide solution with its strength at different temperatures. Stainless steel electrodes in bath 3⅛x3½x10 in. The curves, top to bottom, show temperatures by 10-deg intervals from 80 to 160 F

PROBLEMS AND EXPERIMENTS IN DEVELOPMENT

The first problem, and one of the most difficult, was to find a suitable combination of electrode material and electrolytic solution which could be operated continuously for long periods of time satisfactorily. The electrode materials tried were iron, lead, copper, aluminum, zinc, German silver, carbon, nickel, stainless steel, and monel metal. Each of these was tried separately with solutions of sodium chloride, sulfuric acid, acetic acid, copper sulfate and sodium hydroxide. At the outset it was found that many combinations would not work, because there was a definite chemical reaction between the electrodes and the electrolyte as soon as current was passed through them. Even alternating current often induced strong chemical reactions. In certain combinations, even if there was no chemical reaction between the electrodes and the electrolyte, the electrodes were eaten up due to corrosion by the nascent oxygen liberated during the passage of the current. This necessitated the use of a corrosion-resisting metal. Stainless steel and monel metal, used in combination with sodium hydroxide, met the requirements. Monel metal electrodes showed negligible decrease, both in length and weight, after nearly two months of continuous operation.

The large number of experiments necessary for the development of this type of heater showed that the electrolytic heating element has extremely flexible power input charactertistics. Chart 1 shows the effect of strength of solution on its specific resistance at different temperatures.

Results showed that the resistance, and therefore the wattage used by the electrolytic heater, can be varied within a wide range without any change in the physical dimensions of the heater vessel. This great flexibility in power input makes the designing of an electrolytic heater to fit various sizes of incubators quite an easy matter.

In the actual heaters built, the strength of the solution in the heater varied from 1.25 g per liter (single heater) to 9 g per liter (two heaters in series) when the heater was used chiefly for heating, and 220 g per liter when the heater was used primarily as an oxygen generator, in order to minimize the heat produced as much as possible.

Other problems of minor importance which had to be solved so that the electrolytic heater could operate successfully were those having to do with the shape and size of the heater vessel, means of minimizing the effect of liquid level variation, the air circulation, moisture control, and size and construction of the thermostatic mechanism. The solutions to some of these problems have already been mentioned above. (For complete details refer to the author's doctorate thesis, Vol. II, Cornell University.)

Four blank incubation tests were made before actually using the machine to incubate eggs. With the aid of graphic and indicating instruments such as the hygrograph, thermograph, graphic wattmeter, thermometer, ammeter, and voltmeter, the first two tests revealed minor defects in the construction of the incubator shell, heater vessel, and thermostatic mechanism. The third blank test showed that the optimum conditions of artificial incubation, as far as present knowledge goes, can be maintained in the incubator with the electrolytic heating element with a minimum of attention and labor, and for a length of time far in excess of that required for incubating eggs. The fourth blank incubation test was an attempt to modify the oxygen and hydrogen contents of the incubator atmosphere, in addition to maintaining optimum humidity, temperature, and ventilation. It was possible to maintain the oxygen content of the incubator air only a little over one per cent above that of the room air, and only traces of hydrogen could be detected, although a large amount of hydrogen was generated inside the incubator. The reason for this was that a large leakage of outside air into the incubator took place through the cracks and crevices present. Later the oxygen level was held at higher values by using an air-tight chamber.

Two actual incubation tests followed the four blank tests. The first test was made in such a way that the eggs were candled for fertility and embryonic mortality determinations on the 7th, 14th, and 18th days. Beginning on the 20th day, the incubator was opened every 3 hr to determine the time distribution of hatch until the end of hatching. Also, in this test the uppermost tray was not exposed to rapid air movement, the second and third trays were so exposed, and the lowest tray moderately exposed. The percentage hatchabilities in these trays were, respectively, 66.6, 25.4, 28.6, and 47.0 per cent. It is surmised that the frequent opening of the incubator during hatching and the exposure to rapid air currents interfered adversely with the hatching.

In the second incubation test, the incubator was not opened until the end of hatching, except when the charts of the hygrograph and thermograph were changed at the end of each week. Also, the eggs in the two upper trays were not exposed to the air current, while those in the lowest one were so exposed. The third tray was empty because of lack of eggs. Under these conditions the percentage hatchabilities in the trays were, respectively, from top to bottom, 74.2, 73.2, and 53.2 per cent. These percentage hatchabilities showed marked improvement over those of the previous test.

Although I do not consider, by any means, that the electrolytic system of incubation is necessarily better than those systems now in general use, still I feel that the data collected regarding the operation of the electrolytic system justify its further development, especially for experimental

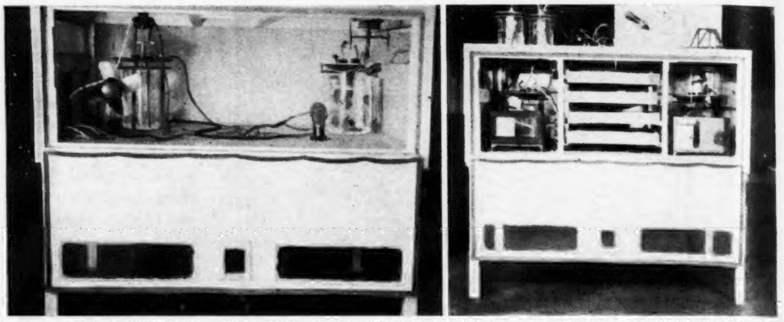


Fig. 6 Electrolytic heaters in position (left) and incubator ready for test (right)

incubation, and I hope that in the future it will come into more practical use.

SUMMARY AND CONCLUSIONS

1 The electrolytic heater for incubators varies power input without at any time cutting it off entirely, thus being much more sensitive than heaters regulated by breaking the current. It is capable of maintaining a practically constant temperature, even if the incubator room temperature fluctuates widely. This method of electric heating eliminates the use of breaker points and protective condensers, and makes possible a simple arrangement of temperature regulating mechanism.

2 Desirable operating characteristics of the electrolytic heater are due almost entirely to the combined use of glass sleeves around the fixed and movable monel metal electrodes immersed in a bath of sodium hydroxide. Besides making possible a sensitive temperature control, the glass sleeves provide a means of separating the oxygen and hydrogen gases liberated during the operation of the heaters when direct current is used. The oxygen thus liberated can be added to the incubator atmosphere. When this atmosphere contained about 32 per cent oxygen, it was found to be beneficial to the embryo as far as hatchability, growth, and mortality were concerned. This simple, reliable, and easily regulated source of oxygen gas makes possible important experiments to determine the effect of high oxygen concentrations on the chick embryo during the last three days of incubation. It is surmised that the high rate of mortality during this period is due to a deficiency of oxygen in the egg air space in which the embryo breathes. It is also interesting to speculate on the combined effect of high oxygen content and high temperature on the growth of the embryo. Each of these factors, separately, accelerates embryonic growth.

Use of the glass sleeves makes the maximum power input independent of the height of the liquid, and also maintains a uniform temperature throughout the liquid bath.

3 A simple but effective scheme of air movement is used to maintain a uniform temperature in the incubator. A relatively rapid unobstructed horizontal air movement takes place at the bottom of the egg chamber below the lowest egg tray, where the heaters are located, and an imperceptible upward movement through the eggs distributes the temperature evenly throughout the rest of the chamber. This improves hatchability.

4 The stored heat in the liquid maintains the incubator temperature above the danger point for several hours after a power failure. This is important in rural areas.

5 The electrolytic heater has an extremely flexible power-input characteristic, which simplifies its design to fit incubators of various sizes.

6 Finally, it can be said that the electrolytic heater is ideally suited to electric incubation, because in this device we have a simple, reliable, flexible, and inexpensive source of sensitively controlled heat, a means for automatically providing the necessary moisture for incubation, and a copious supply of vital, life-giving oxygen.

Farmers as Building Craftsmen

(Continued from page 204)

and skilled laborers in farm production than as the unskilled, semi-skilled, or even skilled construction workers they might become.

The help these business farmers can use in the matter of farm buildings is help in seeing the contribution better building might make to their production program, work effectiveness, and farm life; help in determining their building requirements; help in evaluating buildings in terms of annual cost and contribution to net income; help in recognizing sound construction; and help in giving it proper care and maximum use. They need local rural builders and building material dealers trained to understand and help meet their building requirements. They need help in financing the buildings necessary to and justified by their efficiency as specialists in farm commodity production. They need the help of research to define more accurately the use requirements of farm buildings and to determine means of meeting those requirements most economically. They need the help of the building materials industry in the form of improved materials, low-cost prefabricated buildings and structural units, and more accurate information as to proper applications, cost, performance, maintenance, and service life of building materials.

Neither self-sufficiency nor specialization is a cure-all for economic difficulties. Subsistence farming, the other name for self-sufficiency, implies its limitations. It can produce little more than a bare subsistence. Specialization is a greater gamble, and requires a higher intelligence, more exact information, a higher level of human relationships, and a greater adaptability to changing conditions, but it has demonstrated that it can provide much more than subsistence for those who are capable of efficient, specialized productive work. The way of progress for business farmers is toward increased understanding and a more accurate application of the principles of specialized production and exchange economy, in order to make the most of its possibilities.

Helping farmers with their farm building problems implies recognizing the economic realities confronting individual farmers. For some, doing more of their own building work would be a step forward, while for others it would be a step backward. Agricultural engineers may well avoid the incongruity of becoming highly specialized exponents of the supposed evils of specialization.

Watershed and Hydrologic Studies on the Central Great Plains

By J. A. Allis and L. L. Kelly
MEMBER A.S.A.E. MEMBER A.S.A.E.

WIDESPREAD droughts and disastrous floods of recent years have focused public attention on the importance of the conservation of our natural resources of water and soil, and the control of surface runoff.

Until comparatively recently, little work has been done which would add to the knowledge of hydrology and its relation to agriculture. The 74th Congress recognized, in enacting the Soil Conservation Act of 1935, the need for soil and moisture conservation. Funds for research were provided by this act, and when the Soil Conservation Service was organized, a hydrologic division was included among the research divisions established. One of the functions of this division is the determination of the effect of land use upon runoff and erosion. This work is being carried out on several experimental watersheds. These watersheds have been located so that they are as nearly as possible representative of rather definite areas. The one covered by this paper is located near Hastings, Nebraska, and is considered to be representative of the Central Great Plains region, which consists of central Nebraska and South Dakota, and to some extent of certain regions of western Nebraska, eastern Colorado, northern Oklahoma, North Dakota, and Kansas.

A paper presented before the Soil and Water Conservation Division at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 6, 1940. Authors: Respectively, project supervisor and assistant hydraulic engineer, hydrologic division, Soil Conservation Service, U. S. Department of Agriculture.

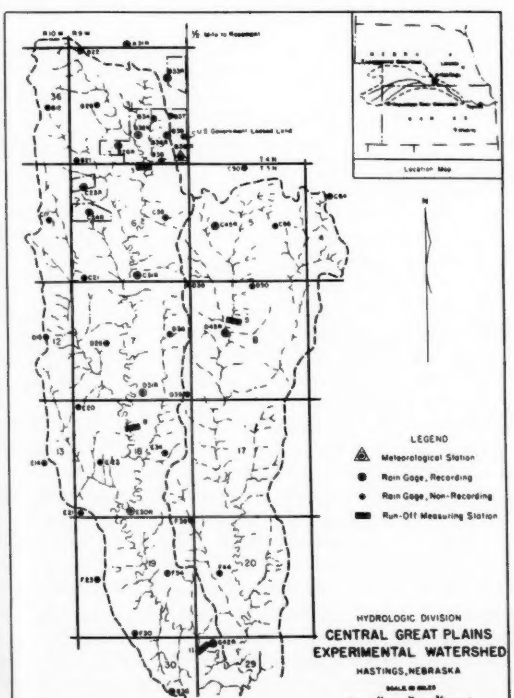


Fig. 1 Location of meteorological station, runoff measuring stations, and rain gages on the Central Great Plains Experimental Watershed Area

At the stations all the experiments possible are put on a natural watershed basis. In the past, most runoff studies have been on small plots. These plot experiments have been valuable, but information is needed that will make it possible to tie the plot studies in with the larger watersheds, formed under natural conditions, which make up our agricultural areas.

Selection of Area. In selecting this watershed it was desired that the area selected should be representative of the Central Great Plains with respect to (1) nature and extent of erosion, (2) general soil type, (3) predominant land-use practices, (4) type of topography, and (5) major geologic formations. These factors were determined in an office study which was made from various maps and existing information.

The next step was to eliminate areas that were not typical with respect to any of the above factors. This was done by making composite maps showing the different factors and then eliminating all areas not typical.

Remaining areas were then critically inspected in the field for desirable watersheds within the boundaries of these areas. Final selection of the Beaver Creek Watershed was made on the basis of the above five characteristics and on the basis of number and type of watersheds, size, shape, and drainage characteristics of the watersheds; gaging sites; control of land; and general facilities offered by the regions.

Location and Description. The Beaver Creek Watershed is a tract of 5300 acres located in Webster County, 25 mi south of Hastings, Nebraska, and near Rosemont, Nebraska. The stream system consists of two forks which unite a short distance below the project area. These two forks, with their many small feeder drains, have left the surface of the area split into long tongues of gently rolling uplands.

At the north end of the watershed the elevation is about 2,000 ft above sea level, and at the south end drops to about 1,800 ft. The water drains to the south into the Republican River.

Soils. The parent material of all of the soils of the watershed, except one, the Nuckolls, is Peorian loess. This deposit varies from 0 to 30 ft in depth. Beneath the Peorian, or exposed as in the case of the exception noted, is the loess phase of the Loveland formation, which varies in depth from 0 to 90 ft or more. The wide range in depths of the two loessial deposits is caused by irregularities of the surfaces upon which deposition took place, as well as by the irregularities of the present terrain. The minimum depth of the combined loessial deposits is probably never less than 20 ft.

Most of the soils have deep, friable topsoils, usually with a silt loam texture. The proportions of each of the predominant soil types are Hastings silt loam, 58 per cent; Holdrege silt loam, 10 per cent; Colby silt loam, 7 per cent; and Judson silt loam, 6 per cent. The remaining area is made up of other closely related types.

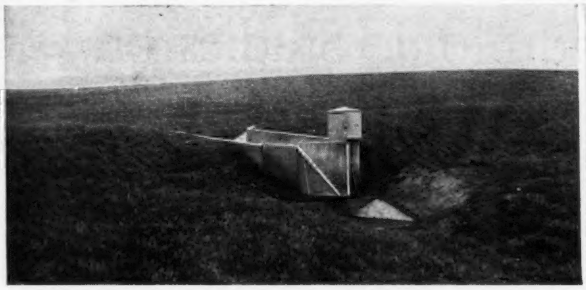



Fig. 2 (Left) View of 3-ft type H flume installation used to measure runoff from small watersheds. This picture was taken on a small watershed which, in 1940, was planted to oats on the contour. Fig. 3 (Right) Gaging station No. 3, to measure runoff from 481 acres: (1) low-water control, (2) submergence gage, (3) high-water control, (4) measuring section

The water table lies at a depth of 40 to 120 ft. The analysis of runoff data is simplified because no water is lost from the soil surface by percolation to the water table, and because no accretion to stream flow occurs from the water table.

Land Use. The native vegetation of this section consisted chiefly of grasses. The region in which the watershed area lies represents a transition from the tall grass to the short grass prairie and is really a mixed grass section. Buffalo and blue grama grasses constitute about 96 per cent of the coverage on the uncultivated areas remaining. Pasture and meadow comprise about 24 per cent of the area; wheat and small grains, 35 per cent; corn and sorghum, 31 per cent; and other crops and uses, 10 per cent.

For the most part, farmers are still using farming practices and methods employed for many years. Few have, on their own initiative, adopted conservation practices.

Climate. The climate of this area is characterized by cold, relatively dry winters, hot summers, fairly heavy summer rainfall, relatively low humidity, and a moderately long frost-free growing season.

Mean annual precipitation for Webster County, as recorded by the Weather Bureau station at Red Cloud is 23.82 in. The greater portion of this, 77 per cent, occurs in the six months from April to September, inclusive. The high intensity of the rains and the hot dry winds during the dry periods between the storms constitute a serious agricultural problem.

Ordinarily, because of the winter winds which drift the snow from the smooth fields of winter wheat and other fields with sparse cover, little of the moisture from snow becomes available for crop growth. Consequently, yields of winter wheat especially are dependent upon the amount of moisture which has accumulated in the soil between the time of harvest and the beginning of winter.

Objectives of the Beaver Creek Watershed Project. Objectives of the experimental work on the Beaver Creek Watershed are (1) to determine the effect of land use on runoff, (2) to study flood flows and flood characteristics, and (3) to collect data for the economical design of agricultural and municipal structures as related to soil and water conservation.

In order to carry out the proposed experiments, 240 acres of land were leased. Construction work was begun in the spring of 1938. The major phase of the construction work is completed and four studies are now in progress.

(I) *The Effect of Land-Use and Soil Conservation Practices on Runoff from Small Watersheds.* The objectives of this experiment are (1) to compare the effect of straight-row, contour farming and strip-cropping on the runoff from intertilled and small grain crops, and (2) to compare the runoff from native meadow and untreated pasture land with that from cultivated land.

In this experiment, 3-ft type H flumes equipped with waterstage recorders were installed on eighteen small watersheds selected in 1938.

Six self-registering rain gages and a first-class meteorological station were installed to provide necessary information on precipitation and weather conditions. (See Fig. 1 for location of all rain gages and the meteorological station.) The traces made by the recording rain gages are used to determine the time, intensity, and amount of the rains.

Soil moisture samples are taken at seeding and harvest time on all of the areas. Yields are obtained by the rod row sampling method.

These eighteen watersheds average 3.77 acres and do not vary in size more than about 10 per cent. The boundaries, delineated by dikes, are placed on the natural watershed boundaries wherever possible. Turn strips are left between adjacent watersheds. Farming operations are extended beyond the boundaries to eliminate border effect as much as possible.

The eighteen watersheds are in the following land use: Triplicate watersheds of native grass; triplicate watersheds of strip crops with corn and oats; duplicate watersheds each of corn, oats, and wheat planted in straight rows, and duplicate watersheds each of corn, oats, and wheat planted on the contour.

From this experiment can be obtained, then, the effect on runoff of (1) contour planting versus straight row planting, (2) strip-cropping versus contour planting or straight-row planting, and (3) native grass land versus cultivated land.

Studies of the effect on runoff of crop residue and subsurface tillage, as compared with the prevailing methods of farming, are being started this year. Recent work conducted cooperatively by the Soil Conservation Service and the Nebraska Agricultural Experiment Station has indicated that keeping the land covered with crop residue, when it is not growing a crop, is an effective means of reducing the amount of erosion by both water and wind. This experiment requires six new watersheds, which are now being established.

On these six new watersheds a rotation of corn, oats, and wheat will be followed, and planting and cultivation will be in straight rows, thus making it possible to use as check areas six of the watersheds already established and planted to the same crops.

For the tillage of these watersheds, the agencies mentioned above have selected or designed machinery that will cultivate the soil and control the weeds but will also leave the crop residue on the soil surface. The implement to be used to replace the plow, lister, and disk is a field cultiva-

tor which has wider shovels than the common duckfoot cultivator. It, however, does not leave the ground ridged as does the duckfoot cultivator. All other implements to be used have been chosen so that the surface covering of residue will be retained.

(II) *The Effect of Intensity of Grazing and Contour Furrows on Runoff from Pasture Land.* The objectives of this experiment are to determine (1) the effect on runoff of relatively heavy versus moderate grazing, and (2) the effect on runoff of contour furrows under both moderate and heavy grazing.

In 1939 this experiment was laid out in duplicate on two pastures about one-half mile apart. In each of the pastures, four plots, 100 ft wide and 300 ft long and with the long axis running in the direction of the greatest slope, have been established. One set of plots has an average slope of approximately 9 per cent and the other set an average slope of approximately 6 per cent.

The plots are handled as follows: (1) Furrowed and heavily grazed, (2) flat surface and heavily grazed, (3) furrowed and moderately grazed, and (4) flat surface and moderately grazed.

At the lower end of each plot 2-ft type H flumes, complete with waterstage recorders, have been installed to measure the runoff. A recording rain gage has been located at each set of plots.

A survey of basal vegetal cover on the plots was made in 1939 in cooperation with the Nebraska Experiment Station. A system of small permanently located transects was established on each plot and the basal cover recorded. Improvement of the stand or change in the cover will be measured by periodical resurveys on the transects.

Several fenced clipping transects at each set of plots allow a comparison of the growth on the flat plots and the furrowed plots.

(III) *Characteristics of Flood Runoff from Agricultural Areas of Different Sizes.* Objectives of this experiment are to study the characteristics of runoff from watersheds of various sizes and the factors affecting them under (1) prevailing land use practices and (2) conservation practices.

In 1938, three gaging stations, Nos. 3, 8, and 11, were put in operation on the west fork of Beaver Creek. These stations have drainage areas of 481, 2086, and 3490 acres, respectively. Continuous runoff records have been obtained since they were established. The gaging stations consist of a 3:1 broad-crested notch capable of discharging flows up to about 100 cfs, above which capacity the water is allowed to flow over the flood plain. Waterstage recorders measure the stage 10 ft upstream from the notch and the amount of submergence of the notch. The recorders are housed in recorder shelters mounted over stilling wells which are connected to the stream by intake pipes (Fig. 3).

The V notches have been calibrated in the hydraulic laboratory in Washington for free flow and for submerged flow up to about 90 per cent. When the submergence exceeds 90 per cent, or when the discharge is above the capacity of the notches, current meter discharge measurements are made in order to define the stage-discharge relation curve. The flat gradients of the streams cause submergence before the notches have reached their full capacity. Adverse weather conditions, night storms, and muddy roads are the main difficulties encountered in making measurements.

In 1939, gaging station No. 5, which has a drainage area of 411 acres, was established on a tributary of the east fork of Beaver Creek. This area will be placed under the best known conservation practices after sufficient comparative data have been obtained from it and from the area above gaging station No. 3. Little information on runoff from areas of this size in the Central Great Plains region is available.

(IV) *The Influence of Land Use on Infiltration on Natural Watersheds.* Experiments on the effect of soil type, slope, and surface conditions on the intake of water were begun in 1938 at Lincoln, Nebraska. For conducting these tests, a sprinkling apparatus was constructed similar to that developed by the Soil Conservation Service personnel at the Colorado Springs, Colo., project. Water was applied artificially to small plots which were equipped with collectors for measuring the runoff. Determinations of the amount of water applied, the amount of runoff, and the amount of infiltration were made. The results of these experiments have been published in cooperation with the Nebraska Agricultural Experiment Station.[1]

Comparison of two types of rainfall applicators has been made. The Colorado type, used in the tests mentioned above, was found to give higher rates of infiltration than the later developed F type. This F type equipment has been used for all subsequent experiments because of its better distribution of water, larger drop size, and improved mechanical features.

Correlation of the amount of infiltration measured on the 6x24-ft plots upon which artificial applications of water are made, with the infiltration measured on the same size plots, on 100x300-ft plots, and on 4-acre watersheds under natural rainfall is being studied. The watersheds and plots are on native pasture and meadow land. Because of the few storms in this area in the last two years, it has not been possible to collect sufficient data to make a correlation between natural rainfall and simulated precipitation.

The Central Great Plains Experimental Watershed has obtained about two years of records to date. Only the trends of possible results have been indicated so far. Data for a number of years is required before conclusions may be derived, therefore an analysis can not yet be made. However, a hydrologic bulletin, giving the data up to this time, is being prepared and will be published by the Soil Conservation Service in the near future.

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[1]Duley, F. L. and Kelly, L. L. The effect of soil type, slope, and surface conditions on intake and water. Nebraska Agr. Exp. Sta. Res. Bul. No. 112 (1939)

Rules for Electric Fencing

THE National Bureau of Standards has issued Handbook H36 entitled "Rules for Electric Fences," which will constitute Part 6 of the new edition of the National Electrical Safety Code, the revision of which is now nearly completed.

"Rules for Electric Fences" is a 13-page pamphlet which gives requirements for making the use of electric fences as safe as possible, although it is inherent in such an apparatus that it shall be capable of giving an electrical shock to a person who may touch it, as well as to the animals which it is intended to keep within the fenced enclosure.

Controllers for electric fences are recognized in four types as follows: Battery type, alternating-current type, inductive-discharge type, and capacity-discharge type. The output of the controlling device must be limited to values which are specified for each type.

Other rules deal with the measurement of this output, marking, grounding, tests for insulation, and various other items connected with the proper restriction of the current and with the permanency of the provisions for reasonable safety.

Copies of this handbook can be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 5 cents.

Equipment for Runoff Measurements

By A. L. Kennedy
MEMBER A.S.A.E.

THE Tennessee Agricultural Experiment Station, in cooperation with the agricultural relations department of the Tennessee Valley Authority, has under way a project to study the effect of fertilization and associated farm practices on the erosivity and infiltration capacity of important Tennessee soils. The runoff measurements necessary for the required determinations are made on 1/20 to 1/5-acre plots, under various conditions as to soil type, slope, cultivation, productivity, fertilizer treatment, and cropping systems. Most of the runoff measurements are made by means of portable rain-simulator equipment and measuring devices that can be set up on privately owned fields without damage to crops. The apparatus, which we have developed for these measurements, has the following parts:

1 An automobile chassis converted to serve as a truck in transporting the measuring equipment from place to place; as a tractor in setting up the plots; and as a pumping unit.

2 A 400-gpm centrifugal fire pump mounted on the front of the automobile chassis and connected to the front end of the crankshaft of the engine.

3 Light-weight, quick-connecting irrigation pipe (800 ft), with connecting hose.

4 Light-weight, quick-connecting irrigation pipe (240 ft), with automatic regulating rotary sprinklers spaced every 10 ft.

5 A special plow to insert cotton belting in the ground for the purpose of isolating the plots.

6 Two-ply cotton belting, 6 in wide (2000 ft), for border strips for sides and upper ends of plots.

7 Two-ply cotton belting, 10 in wide (160 ft), to collect the runoff at the lower ends of the plots.

8 An automatic runoff sampling device, calibrated and adjusted to shunt a very small aliquot part of the runoff into a catch bucket or graduated bottle.

9 Several 2 and 3-gal bottles, graduated to show the runoff directly in terms of inches.

10 A 20-kg solution balance.

Author: Assistant agricultural engineer, Tennessee Agricultural Experiment Station, department of agricultural engineering.

Belt-Threading Plow. To isolate the selected plots for runoff studies, a special plow was developed to thread cotton belting into the ground along the plot borders. The plow has two reinforced 1/16x12-in steel plates, welded to a 1/8-in spacer strip at the bottom parallel edges, and fastened together also at the top edges of the rear parallel ends. The front end of one of the steel plates is twisted outward and shaped to let the belting feed in at the top. The bottom part, which goes in the ground, is 1/4 in wide, and the cutting edge is a straight line for the entire length, which is 3 ft. In operating position, the plow is tilted backward so that when the rear end is in the ground the desired depth, the front cutting edge is slightly out of the ground.

With a roll of belting of the desired length in place, the end is threaded into the front end of the plow and on out through the narrow enclosed passageway, and is fastened to the corner stake of the plot. The belting is thus in position to be threaded in the ground by the plow as it is pulled along. When the ground is soft the plow can be pulled by one man. For hard ground it is propelled and forced into the ground by the truck. (Fig. 1).

Two-ply cotton belting has worked satisfactorily with the plow and as border strips for temporary plots.

Floating Rotary Sprinkler. A floating rotary sprinkler was developed, which will automatically apply water at a predetermined definite rate on a square area when the line pressure is 12 psi or more. The sprinkler in its operating position consists of a vertical supply tube and a distributor assembly that is free to rotate and move up or down on the tube. Water is supplied laterally to the distributor assembly through four equally spaced slots, or series of holes, near the upper closed end of the supply tube. This spacing of water passages varies the effective delivery pressure at the nozzles as the distributor rotates, resulting in the square pattern of the ground sprinkled from each sprinkler head.

The babbit bearing at the lower part of the assembly fits closely about the tube to prevent leakage and to cover up the lower portion of the slots, for regulating the supply of water to the distributor assembly. As water pressure increases, the floating rotating head raises on the supply tube and proportionately reduces the (Continued on page 220)

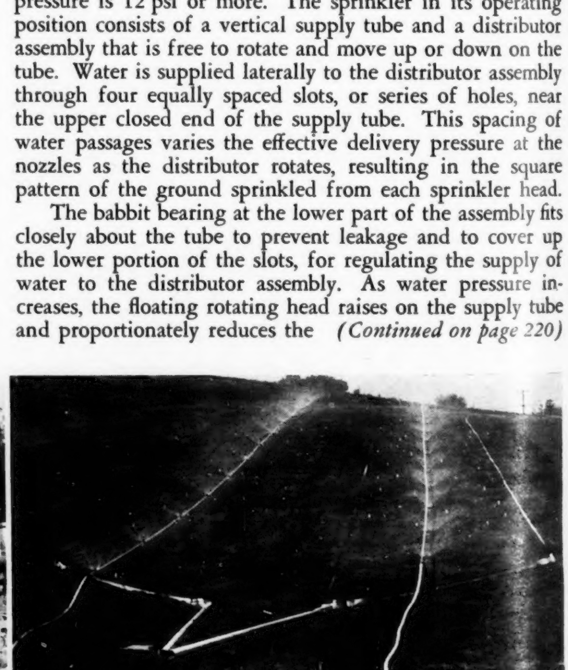

Fig. 1 (Left) Threading cotton belting in sod land for plot border strips. Fig. 2 (Right) Measuring the runoff resulting from a simulated rain on two 1/20-acre plots with 25 per cent slope

Results of Barn Hay Drying Studies

By John W. Sjogren and P. D. Rodgers
MEMBER A.S.A.E. JUNIOR MEMBER A.S.A.E.

ON A year-to-year basis, the production of clover and timothy hay amounts to about 50 per cent of the combined production of all other hays in Virginia. The difficulty of curing is the principal limiting factor in the production of good clover hay under climatic conditions in the state. It is estimated by agronomists and dairymen that about 25 per cent of all clover cut for hay in the state is lost because of adverse weather conditions at harvest time. This means an annual loss of about 125,000 tons of clover hay.

Consequently, when the Tennessee Agricultural Experiment Station in cooperation with the Tennessee Valley Authority announced the development of a low-cost hay drier believed practical for the average farm, investigations were immediately contemplated to determine the value of this type of drier under Virginia conditions. A project was initiated late in 1939 and in the spring of 1940 one of the barn-type hay driers was installed at the Virginia Agricultural Experiment Station. The departments of agricultural engineering and of dairying cooperated in conducting tests and investigations to determine the practicability and effectiveness of this drier for improving the quality of clover and other hays harvested under Virginia conditions. Similarly, observations were made of two other barn hay driers, one employing artificial heat, installed in the spring of 1940 by farmers in southwest Virginia.

DRYING WITHOUT SUPPLEMENTARY HEAT

Experiment Station Studies. The hay drier installed by the experiment station was placed in a barn which had mow floor dimensions of 39x120 ft. The duct system was placed in one end of the mow and covered a floor space of 37x39 ft, or an area of about 1445 sq ft. The system consisted of two main ducts 15 ft apart and running parallel to each other across the mow floor, converging at an electrically driven blower located in a shed at the side of the mow. The air was distributed from the main ducts into the hay by means of lateral ducts spaced 5 ft apart. A double blower on a single shaft, capable of delivering 12,500 cfm of air, was used for this drier. The blower was driven by a 5-hp electric motor which was controlled by a time switch and a humidistat placed in the starting circuits.

Previous tests at other institutions have shown that loose hay of more than 20 per cent moisture content cannot be stored without undergoing considerable heating and deterioration in quality. Under favorable weather conditions it ordinarily requires at least two days of field curing to bring hay to this moisture content. If the weather is not favorable, it will take several days, with the result that a large percentage of the leaves will be lost and the hay will become discolored and lose much of its feed value. Tests show that newly cut alfalfa hay, when exposed to the sun, can be brought to a moisture content of 45 to 55 per cent in from 4 to 6 hr of field curing. In operating the drier, therefore, an effort was made to cut the hay in the morning and place it on the drier in the afternoon. It was not always possible to follow this procedure because of frequent rain; in fact, most of the hay placed on the drier during the season was exposed to one or more rains.

Four batches of hay were cured on the experiment station drier during the 1940 season.

The first batch was of approximately 17 tons of first-cutting red clover hay containing some volunteer barley. The hay averaged 50 per cent moisture when placed on the drier, and was reduced to 22 per cent by 116 hr of fan operation during 13 days. The weather during the drying period was cloudy and rainy much of the time. Weather records show that it rained on seven of the thirteen days.

A second filling consisted of about 30 tons of first-cutting of red clover hay from another field. This hay contained considerable weeds and had a moisture content of 45 per cent when it was placed on the drier. After 189 hr of fan operation, during 21 days, the moisture content had been reduced to an average of 23 per cent. The weather was cool and rainy, with a high relative humidity.

For the third filling 13 tons of second-cutting red clover hay were used. Only one-half of the duct system was covered by this cutting, which was placed on the drier August 3. On August 9, seven loads of alfalfa hay containing about 30 per cent weeds, were placed on the other half of the duct system. These two cuttings required 354 hr of fan operation to complete the drying process. The weather was cool and much rain fell during the drying period from August 3 to August 27. When removed from the drier, the hay contained about 25 per cent of moisture. Similar forage, cut and cured in the field during this period, was worthless for hay.

The last batch of hay cured on the drier consisted of 15 tons of clover and weeds and about 5 tons of third-cutting alfalfa. This hay was placed on the drier September 11 and remained there 16 days, requiring 149 hr of fan operation. The weather was clear and cool during this period.

Hay obtained from this drier during the 1940 season was judged by practical farmers to be a No. 2 mixed hay. No attempt was made to officially grade the hay. The barn-cured hay was relatively free from mold and dust, and a high percentage of the leaves remained on the stems. In feeding both barn-dried and field-cured hay, the herdsmen observed that dairy cows seemed to eat barn-dried better than field-cured hay.

FARM USERS SATISFIED

Field Studies. Field studies were made during the 1940 season on two barn hay driers installed in southwest Virginia. One of these was installed on a farm near Marion and consisted of a duct system similar in design to that recommended by the Tennessee Valley Authority. It was installed in a bank barn and covered one-third of the mow floor area, or 34x34 ft. A double blower on a single shaft operated by a 7½-hp portable motor was installed with this system. The blowing equipment was placed in a shed built on one side of the barn.

The first cutting of red clover and timothy was placed on the drier during a rainy period and contained 65 to 70 per cent moisture. The hay was placed on the drier to a depth of 20 ft, which settled to a depth of 17 ft.

The report of the farmer indicated that the hay had molded at the top, which he attributed to the fact that it

A paper presented before a meeting of the Southern Section of the American Society of Agricultural Engineers at Atlanta, Ga., February 7, 1941. Authors: Respectively, assistant agricultural engineer, Virginia Agricultural Experiment Station, and fellow in agricultural engineering, Virginia Polytechnic Institute.

was too green and wet when placed on the drier. It was estimated that the blower had been operated about 148 hr using 738 kwhr of electricity, or 18.4 kwhr per dry ton. Although this drier was operated under unfavorable weather conditions, the farmer was satisfied with its operation.

Drier with Artificial Heat. The other drier observed in the field tests was installed by a farmer near Dublin, Virginia. This drier was designed for the use of heated air in connection with the barn hay-drying system. The ducts were installed in a hay mow 16 ft wide by 60 ft long, with the main duct running through the center of the mow on the long axis. A blower of the double-fan type was operated by a 5-hp electric motor. Heat was supplied by a hot-water furnace with a grate area of 3 sq ft. The furnace was fired by an automatic stoker. Radiators totalling 900 sq ft of surface were placed in an enlarged section of the delivery duct. The air forced through the delivery duct was raised an average of 20 F above atmospheric temperature by maintaining a water temperature of 160 F.

About 70 tons of alfalfa hay were cured on this drier during the season and observations were made on its operation. The weather conditions during the entire haying season were unfavorable for curing in the field.

The average moisture content of the alfalfa hay as it was placed on the drier was 50 per cent. The longest time for a batch to remain on the drier was 187 hr, while the shortest time recorded was 34 hr. Average time for all cuttings was 97 hr, with the blower operating day and night. The amount of hay on the drier had considerable influence on the length of time required to dry the hay. Depth of hay on the drier varied from 4 to 8 ft for all batches. Quality of the alfalfa hay cured on this drier was considered high. The hay retained a large percentage of leaves and its color remained a bright green. The operator was well satisfied with the drier.

This drier using artificial heat required an average of 42.85 kwhr of electricity, and 240 lb of coal per ton of hay dried. With electricity at 3 cents per kilowatt-hour and coal at $2.00 per ton, the cost for artificial drying was $1.53 per ton. This estimate includes power and fuel costs only. The farmer sold his hay at the farm for $25 per ton, which gave him a premium of $5.00 per ton above the market. The demand for this hay has been greater than the supply.

CONCLUSIONS

1 The 1940 haying season in southwest Virginia was unfavorable for curing hay. During the months of June, July, and August rainfall was recorded on 39 days. This, together with a low mean temperature, and a high mean relative humidity, made the curing of hay difficult. The results from the drier operation were encouraging.

2 Total cost of the drier installed by the Virginia Agricultural Experiment Station was $436. The total cost of the drier employing artificial heat was $961. The furnace, stoker, and radiators were bought as used equipment. The cost would have been higher if new equipment had been installed.

3 Cost of operating the driers varied with the type of hay cured and the type of drier. The experiment station drier at Blacksburg was operated on an average of 9.4 hr per ton of dry hay, requiring an average of 23.1 kwhr per ton. Resultant electricity cost for operating the drier was 69 cents per ton, at 3 cents per kilowatt-hour.

4 The drier using artificial heat was operated on an average of 10 hr per ton of dried hay, requiring an average of 42.8 kwhr and 240 lb of coal per ton of hay dried. With electricity at 3 cents per kilowatt-hour, and coal at $2.00 per ton, the power and fuel costs for drying with artificial heat was $1.53 per ton.

Equipment for Runoff Measurements

(Continued from page 218)

effective area of the slots through which water passes to the nozzles, making nozzle pressure independent of line pressure above 12 psi. Since the water enters the assembly laterally, the only upward force is the static pressure of the water, and the major downward force is gravity.

When the sprinkler is in operation, these forces, together with the rebounding force of the water leaving the assembly, are constantly at work to maintain an equilibrium. Since the force of gravity, or the weight of the assembly, is the controlling force, and since this remains constant, it follows that the discharge of water from the sprinkler is automatically maintained at a constant rate regardless of line pressures above 12 psi.

A square pattern of distribution is secured by means of two small, properly spaced recesses at the upper edge of the bearing, which permit additional water to enter the distributor assembly when the recesses coincide with the corner slots of the supply tube. (Fig. 3.)

For use in the runoff studies the sprinklers are connected directly to 3-in light-weight irrigation supply pipe, and for routine tests are left in place as an integral part of the pipe. The standard rate of application is 3.7 in per hour, and for this rate the sprinklers are spaced every 10 ft on the pipe. One-half this rate can be secured by the removal of every other sprinkler, or twice the standard rate can be secured by the use of the two complete sprinkler systems on one 1/20-acre plot.

Runoff Measuring Device. A light-weight portable automatic runoff sampling device was developed to take a small aliquot part of the runoff. The composite sample is taken by an open-top intercepting trough that automatically passes under a vertical discharge aperture of the runoff flume at a definite velocity and at regular intervals. The sample, intercepted by the trough as it passes horizontally through the falling stream of runoff, flows out at one end of the trough into a graduated bottle. The intercepting trough is operated by a tipping bucket that is filled at a definite rate by water from an orifice under a constant head. (Fig. 2).

The composite sample caught in the graduated bottle is a definite predetermined per cent of the total runoff from the plot. No settling tank is required, and all the runoff passes through the sampling device. Therefore, the total runoff, in terms of inches of runoff, can be read directly from the graduations on the bottle.

The dry weight of soil in the composite sample is determined in the field by methods developed in cooperation with the general chemistry department of the Tennessee Station.

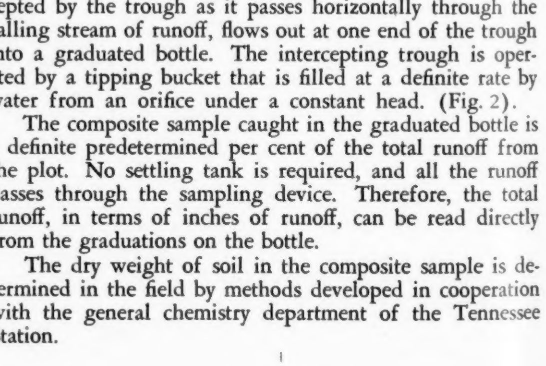

Fig. 3 Detail of rotary sprinkler assembly for delivering water in a uniform square pattern

The Influence of Electric Heating Systems on Sweet-Potato Storage House Construction

By G. H. Dunkelberg
JUNIOR MEMBER A.S.A.E.

THE sweet potato is the most important vegetable crop in the South, and although it occupies a prominent place in the southern diet, an increasing percentage will be sold in the future as a cash crop. Since the roots are harvested in a comparatively short time and released for sale or home consumption over the greater part of the year, large quantities must be stored.

The sweet potato is a living organism. Environmental conditions in the storage house must be favorable for a long storage life. In a rational approach to the design of a sweet-potato storage house, we must know what a sweet potato is and how it responds to certain conditions. Some of these responses have been studied by various plant physiologists, pathologists, and horticulturists, and the results are most valuable. Others have not yet been determined, especially from an engineering viewpoint. A brief resume of the life of the potato and its responses to environmental conditions would seem helpful at this point.

About four or five weeks after the plants are set in the field, some of the roots at the base of the plant begin to thicken and become fleshy. From then until the time of harvesting, the sugars manufactured in the leaves are transported to the roots and changed to starch. Approximately 80 per cent of the carbohydrate content consists of starch and the remainder of various sugars. When the roots are young and slender, the skin consists of a layer of living cells, which can withstand little of the stress or strain caused by either the rapidly growing potato or mechanical injury. As the root develops, this layer is replaced by a more permanent and elastic set of tissues which retains the water and keeps out rot-producing organisms.

At harvest time this new skin is not fully developed and is easily injured. During harvest, the roots are always wounded. If not cut by the harvesting machine or bruised in handling, the potato always has one wound where it has been severed from the stem. If the potatoes are to have a long storage life, their wounds must be healed quickly and the skin developed rapidly. If this is not accomplished quickly, water necessary for life processes escapes and the potato shrinks badly. In addition, disease organisms are able to enter the potato and thrive readily on the moist sugary materials.

For the temporary protection of these wounds, sap which contains unsaturated fatty acids collects in the tissues immediately under the cut surface. These fatty acids cream to the surface, where they combine with oxygen to form a layer of varnish-like material called suberin. The layer of suberin seals in the water and prevents the entrance of rot organisms. Protection by suberin is temporary, since it is nonelastic and cannot withstand the stresses and strains due to osmotic changes within the tissue of the potato.

Under further favorable conditions of temperature and humidity, a permanent layer of cells is developed below the suberized layer, which divide and form a permanent, elastic set of tissue called the periderm. At the same time, the uninjured skin develops into a permanent periderm which gives cured potatoes their "velvety" feel.

Quick suberization requires temperatures of 80 to 85 F (degrees Fahrenheit) and a relative humidity of 80 to 85 per cent. A lower temperature or humidity will retard or even inhibit suberization. Suberization precedes wound-periderm formation, but fortunately the factors which favor the former also favor the latter. Wound-periderm will form readily at temperatures from 80 to 90 F, provided the relative humidity is sufficiently high (80 to 95 per cent). Temperatures above 90 F may cause the roots to decay, and relative humidities high enough to cause condensation on the surface of the potatoes would likewise produce conditions favorable for the development of storage rots.

While the wounds are being healed and the skin is being thickened, certain changes are taking place within the potato. Most important is the speeding up of the rate of respiration, a process which uses the sugars of the roots as a source of energy. These sugars break down into carbon dioxide and water, with the liberation of energy, which is essential in keeping alive the organism. The carbon dioxide and water escape through the skin into the air; thus part of the loss in weight is due to carbon dioxide and the other part is due to water. The water loss is replaced by the water of respiration. Percentage of water in the potato remains practically the same before curing, after curing, and during the storage period.

At the same time, part of the starch within the potato

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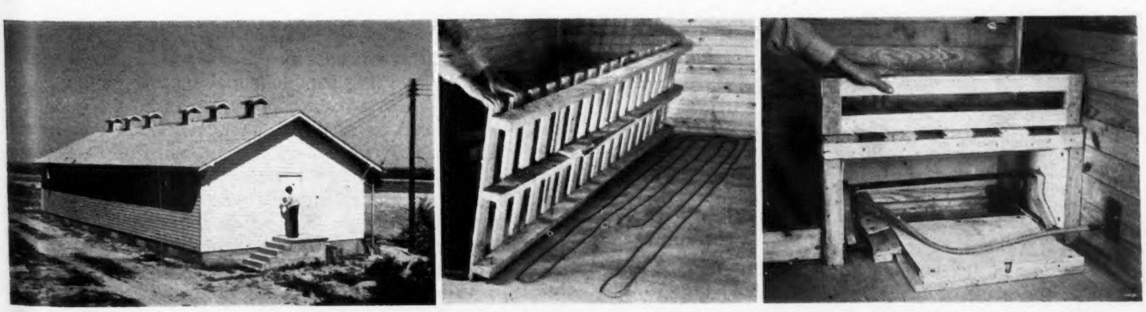

(Left) Community sweet potato curing and storage house, electrically heated, at Graycourt, S. C. (Center) Soil heating cable is used as the heating element in this house. (Right) Electric strip heaters over floor ventilators warm incoming air (Photos by S. C. Extension Service)

is changed into dextrin, which gives cured sweet potatoes a soft and juicy flesh. This change is no index of water contained. Curing is essentially a wound-healing and skin-forming process, and a changing of starch to dextrin. It is not a drying process.

After the potatoes are cured, they must be stored until they are sold or used. At the proper storage temperature (50-55 F) the respiration rate is comparatively low. Sugars are used up slowly. Some shrinkage will occur, due to evaporation of water through the skin. This evaporation can be retarded by maintaining a high humidity within the storage house, but it must not be high enough to cause condensation. Observations at Clemson College indicate that a relative humidity of 80 to 85 per cent does not permit condensation.

Little information is available concerning the sugar changes during the storage period. Some tests have shown that sucrose, or cane sugar, begins to increase at the beginning of the storage period and continues to increase slightly to about March 1. After this time some of the sugars change back to starch. The purpose of the storage is, therefore, essentially the maintenance of a low rate of respiration in the potatoes. It must be sufficient to keep the organisms alive, but low enough to keep shrinkage and loss of weight to a minimum.

From the above discussion we may conclude that an ideal sweet-potato curing and storage house is one in which optimum environmental conditions of temperature, humidity, and air change can be easily and economically maintained. Information as to optimum air change is not available at the present time, except in so far as it affects the maintenance of temperature and humidity. Controlled experiments are now being contemplated at Clemson College to determine the ventilation requirements of sweet-potato storage houses.

PROBLEMS OF SUPPLEMENTARY HEATING

In the northern part of the sweet-potato producing area it is necessary to provide some form of artificial heat to maintain the desired temperatures. Stoves of various types, used in the past, have not been entirely satisfactory. Data secured in a new, well-constructed, coal-stove heated house during the winter of 1938-39 showed wide variations in temperature. In the 2000-bu room in which potatoes were stacked ten crates high, the mean difference in temperature in the top and bottom crates during the curing period was 12.35 F. Average difference during the same period for the two most widely varying locations was 15.7 F, while variations of individual lots were sometimes over 20 F.

Later on, when temperatures were reduced for storage, differences were not as great, especially when the stoves were not in operation. However, the mean difference between the top and bottom crates during the storage period was 5.0 F. Differences in loss of weight in the same locations were 3.57 per cent during the curing period and 3.13 per cent for the entire curing and storage period. One lot lost over 18 per cent of its original weight during its stay in the storage house.

Electricity as a source of heat is now being used in sweet-potato storage houses in an attempt to provide more uniform environmental conditions. Data taken during the winter of 1939-40, in the storage house at Clemson in which potatoes were stacked eight crates high, show the difference between the top and bottom crate during the curing period to be 5.9 F. For the entire period, the difference was between 3.1 and 4.1 F. Fluctuations in relative humidity were small, due in large measure to the small fluctuation in temperature. These results with electricity show much improvement in the maintenance of environmental conditions when compared with stoves; however, results must be studied from several viewpoints.

During rural electrification day of the annual farm and home week held at the University of Georgia in 1939, C. J. Hurd stated that any new use of electricity on the farm should do a better job, perform a task cheaper, do a job previously impractical, or make the farm more self-sustaining.

CONSTRUCTION TO MAKE THE MOST OF ELECTRIC HEATING

Electricity, as a source of heat in sweet-potato curing houses, has been shown to meet these requirements when properly installed and operated. However, the construction of the storage house affects, either directly or indirectly, every one of the above points.

In order to do a better job of curing and storing the roots, the house must be sanitary and capable of being cleaned to eliminate rot organisms. The building must be tight and well insulated, with positive ventilation controls for the maintenance of optimum environmental conditions. To secure a uniform temperature throughout the house, it is necessary to have a well-distributed heat supply, an elimination of hot and cold spots, and a method of preventing wide fluctuations of temperature at the heat source. The above heating conditions cannot be obtained in a practical manner with stoves, but are relatively easy with electric heaters controlled by thermostat. Uniform relative humidity can best be obtained by maintaining a uniform temperature in connection with a positive supply of moisture. Thermostatically controlled heaters will take care of the temperature and the moisture supply can be built into the house.

The growing and marketing of sweet potatoes is one part of the crop diversification program which makes the farm more self-sustaining. However, to realize the greatest value from the crop, the farmer must be assured that his potatoes will not be lost or lowered in quality during the curing and storage period. A curing and storage house, properly constructed and operated, with heating equipment that allows optimum conditions of temperature and humidity to be maintained, will reduce loss from both shrinkage and rot. Rot losses in the electrically heated house at Clemson for the last two seasons have averaged only one potato per bushel.

Wood and coal will produce from five to ten times as many units of heat for the same energy cost as will electricity. On the other hand, wood and coal heating plants require considerable attendance, while no appreciable amount is required by electric heaters, especially when regulated by a thermostat. Due to this difference in basic heat cost, particular attention must be paid to the construction of the building and to the operation of the system, so that heat losses may be lowered.

Walls and ceilings of the better constructed houses are usually of several thicknesses of wood sheathing and are made tight by building paper. It may be that some type of commercial insulating material may prove more economical than the present practice. Lumber, particularly southern pine common, has risen about 20 per cent due to defense activities in the southeastern states. Completion of cantonment building in the spring will relieve the pressure somewhat, but authorities do not expect the price to drop to predefense levels. Regardless of the insulating material used, with the high humidity necessary in a sweet-potato house, a vapor barrier on the inside would improve the insulating value. The elimination of windows in the house would lower the heat loss (Continued on page 225)

Can Agricultural Engineers Solve Tenant Problem?

By Roy E. Hayman
MEMBER A.S.A.E.

SOME eight years ago it was my privilege to make a survey of some 32,000 farms in Oklahoma. This survey revealed some extremely interesting facts regarding standards of living, income, and attitude of mind of farm people generally. Our findings stimulated us to additional study and investigation.

In general, the findings were as follows: Approximately 62 per cent of the farms in the state at that time were operated by tenants. Variations ranged from more than 90 per cent in the counties along the eastern side to slightly more than 15 per cent in some counties in the western part of the state. A further search disclosed that, at that time, the tenants moved on an average of every 14 months. We also discovered that a written contract between tenant and owner was a rather rare thing. After summing up the operations of many of these farms, we arrived at one conclusion, namely, that the so-called cash crop farmer is not able to work enough days in the year at the job of plowing, planting, cultivating, and harvesting his crop to justify his existence. We further found that numbers of farms were mechanized, so much so in fact that the farmers had mechanized themselves out of a job. These conditions are challenging to an engineer. I say challenging because the engineer, in the main, has been responsible for the mechanization of all industry, as well as of agriculture. I much fear that the engineers have failed to take into consideration the fact that man is a human being and can not be discarded as an obsolete machine; that the construction and operation of machines to save labor is not necessarily a good thing. As a matter of fact it can be bad, particularly so if the manpower replaced becomes a liability to society.

IRRESPONSIBLE OWNERSHIP

These conditions were further complicated by a problem that is perhaps more or less peculiar to Oklahoma and particularly the eastern part of the state, in that many farms are owned by what we might call, for a lack of a better term, "irresponsible ownership", in so far as agriculture is concerned. These owners are of three general classes, namely, the state, federal government, and individuals who hope that there is oil under their farms. It is quite apparent that little or nothing can be done about the state ownership of farm lands, represented in general by the school land commission of the state, or about the federal government control, represented in general by that land owned by restricted Indians of the state, until enabling legislation is passed. Legislation would be necessary to correct the abuses growing out of the two ownerships, and at this time I am unable to make what I consider a sound recommendation. However, the third group of ownership, which formerly was considered an unsurmountable obstruction to a sound land program can, if the proper approach be used, be made into an asset rather than a liability. In general, the agricultural return to the owner of this type of land has been little or nothing for a long period of time, and during these years the land and buildings in general have deteriorated to a point that considerable effort and money must be expended before they can be considered as economic producing units.

Now let us analyze the tenant's situation. He has little or no credit, I refer you to records of the Farm Security Administration in this matter. Incidentally, I feel that it is doing an extremely good job under the limitations and conditions imposed upon it. Tenant farmers are more or less a roving type of people, always hunting for a better farm or better conditions under which to live. This roving habit in itself precludes the possibility of accumulating various and sundry things that influence the worth of the individual. Furthermore, the lack of a contract that would permit the tenant to profit by any investment of his time in improvement, forestalls any incentive on his part. Also, in many cases, these people are suffering from malnutrition because of the lack of a properly balanced diet, though perhaps they are not actually suffering from hunger.

In combination, these conditions have, over many years, resulted in the physical deterioration of farms and of the farmers and their families in matters of housing, clothing, food, and, in general, their spiritual and moral fiber.

OWNER-OPERATION NO SOLUTION

We have heard the suggestion made that farm ownership will be the solution. This theory can not be accepted, because many of these tenants were farm owners at one time. Furthermore, I refer you to a statement made by one of the leaders of a tenant farm organization, before a governor's investigation board to the effect that the ownership of a farm wasn't the solution because many of the tenants were unable to plan and carry out an intelligent farm program. In other words, there is a real need for supervision.

In order to arrive at a solution, it is necessary that we go back and examine farming operations basically to determine how the farmer may operate a farm so that he can become an asset to a community and society in general, rather than a liability.

There is a school of thought that, basically, farming should involve the production of many things on the individual farm for the farm family's consumption; the production of feedstuffs for livestock contributing to the first condition; use of farm labor in the erection and maintenance of buildings, fences, drainage systems, water systems, and other improvements in operating and living facilities; and production of something to sell to meet necessary cash expenses. In other words, he should not hire anyone or purchase anything that he can more economically do or produce for himself. This school of thought is based on the fact that the successful, going farmers in the majority of cases practice these things.

We can all, I am sure, readily agree that the lack of a long-time lease or rental agreement is not conclusive to any of these things. For instance, all dietitians agree that certain fruits and berries are essential to a balanced diet. In general, these things can not be produced in any one year's

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planting. And there is no incentive for a tenant to plant such things as rhubarb, asparagus, blackberries, dewberries, youngberries, grapes, etc., for family consumption if he has the feeling that he will not be on the farm the next year to harvest the crops. Neither is it easy to justify planting and harvesting the necessary feedstuffs to carry a balanced livestock program, unless there are suitable fences and housing and storage places for the livestock and feeds produced.

Furthermore, there is no argument justifying a tenant in expending his labor to paint a building, for instance, even though the farm owner may furnish the paint, unless he may enjoy the benefits of painting it over at least a goodly portion of the life of the paint applied.

On the other hand, owners have had grievous experiences with many tenants, resulting in a school of thought among the owners that the tenants are generally "no good." My personal and firm conviction is that this is due to one thing, namely, the lack of a contract. We agricultural engineers must deal with agriculture and farms, and in dealing with the farmer, his thoughts and actions are definite factors in the equation with which we work. I personally think that he is a larger factor than many of us have considered him to be. Furthermore, he is a factor that changes with each individual; one that can not be set down on a slide rule. Farm tenancy is not necessarily a bad thing. As a matter of fact, tenancy is good if properly used.

LONG-TERM TENANCY CONTRACTS

If you will make a survey in any given territory, of all farm and all business houses or residences in the towns and cities which the area supports, I feel quite sure that you will find the percentage of tenantry as high or higher for the towns and cities than it is in the country. Yet we hear little or nothing of the plights of business due to tenantry. I feel sure that the sole difference is that, practically without exception, there is a contract covering the relationship and operation of the property between the owner and the tenant. A tenant contract should set out the obligations of the owner and those of the tenant, and provide payment, one to the other, if either fails to live up to his part of the contract. We might say that all of these things can be agreed upon between the owner and the tenant, and in many cases they are, verbally; or the assumption that they have been is verbally agreed upon. But in many cases man's memory is short; association develops friction; friction develops heat; and, in most cases, heat results in destruction. This is just the thing that has happened too often in farm tenancy. I feel that a proper contract can be the lubricating agency that eliminates heat between the farm owner and the tenant.

If it is as simple as that, why not have a contract? All the farm papers have form contracts for farms, but form contracts are of about the same value as the verbal contracts under which these farms have been operated for generations. I feel sure that it is no more possible to have a form contract applicable to all farms and farmers, than to have a contract that will be applicable to all types of businesses and all property occupied and used by the businesses.

Farm tenancy contracts involve considerations of the physical value or condition of the farm; the situation of the tenant, what he is able and willing to do, and how he is to operate the farm; and the situation of the owner, and what he can and is willing to do toward the operation of the farm. With these three conditions properly analyzed and all factors in the open, an agreement can be reached that offers possibilities for the drawing of a contract for the operation of the farm on a basis satisfactory to both tenant and owner.

The reason for discussing this matter is that almost invariably, in modern times, when a job is to be done involving work and production, the job sooner or later has been turned over to an engineer because the engineer is trained in the organization and application of men and machines to natural conditions and materials, to produce or construct the desired commodity. I firmly believe that the agricultural engineer will finally solve this situation between tenants and owners of farms, if a solution is to be reached. I am convinced that legislation and classroom economics will not do the job, though they may be of assistance.

A BEFORE-AND-AFTER STUDY OF CONTRACT INFLUENCE

Now may I give you some concrete evidence of what has been done. I will cite but one individual tenant and the farm which he operates because we have the record from this farm. Furthermore, the operation of this farm has been used as an example for the operation of several other farms; also, some of these farms are apparently much more satisfactory than this one, though records are not as complete. Let me analyze this farm situation very briefly. It is an upland, sandy, blow-sand, black jack farm that was badly eroded and had ceased to produce agricultural wealth for at least 12 years, though the buildings, including the house, were in a fair state of repair. It is a concrete block house. The tenant was more or less a typical tenant farmer, in that he had no funds with which to operate. As a matter of fact, he had less than nothing. He was in debt approximately $700. The owner of this farm realized that he was not getting any agricultural return from it and that before he could do so, he would have to spend considerable money to improve and rebuild the soil. He was perfectly willing to try any sort of program suggested. The tenant, having nothing to invest and being in debt, was not able to purchase equipment to operate a farm in a mechanized way, but was willing to work. A contract was drawn between the owner and the tenant in which definite things were agreed on and the provision for those things that could not be foreseen were to be discussed and agreed upon before any action was taken by either the tenant or the owner. A contract for a five-year period was signed by both the tenant and his wife because under Oklahoma law, the operation of a farm by a tenant and his wife is a partnership; the tenant and wife are partners in the venture. The contract provides that the tenant should have a definite piece of ground on which to grow a garden for his and his family's consumption, on which he is not to pay any portion of rent. The tenant further agreed to plant 25 per cent of the land to a winter-growing legume each year, to build the soil. He further agreed to plow and farm the land on the contour, and to clear and keep cleared at least three acres of the timber land for pasture. He also agreed to deposit in escrow in the bank all the landlord's normal share of rent, being one-fourth of the cotton, one-third of all other row crops, and one-fifth of all produce crops. The farm is of 80 acres, of which approximately 40 acres was broken out and about 40 acres in brush land.

The owner agreed that at the end of each year, if the tenant had performed all of those things set out in the contract, in lieu of paying him for those things done he would have the customary rent money deposited in escrow in the bank. The results of this operation after three years are these: The land has been completely terraced through the contour plowing and farming procedure, and is one of the most effectively terraced farms in the county, or the entire state. It was terraced at no cost for machinery, and in routine plowing, so that the cost to the tenant was practically nothing. The brush land has been cleared off so that, at the present time, the tenant can reasonably and satisfactorily

pasture eight to ten head of cattle, while at the start of his contract two head was the maximum.

The farming methods adopted resulted in an appreciated value and production capacity of the soil, and blowing of the soil has been completely stopped. The benefits that have been built back into that land are so satisfactory that the owner is more than satisfied with his part of the contract. The improvement in the soil and the general production of the farm is such that, to have done this by the expenditure of money through the customary procedure of improving this type of soil, it would have cost the owner several times the amount of rent that has been returned to the tenant. On the part of the tenant, he has become a substantial producing unit in the economic life of the country. He has partially discharged his former indebtedness, and has accumulated a sufficient amount of saleable livestock and equipment to more than discharge all of his obligations. In the meantime, the tenant and his family have lived above the standards of living that usually go along with tenant life. They enjoy a liberal amount of properly balanced food, are better clothed, and enjoy some of the luxuries of life. They now enjoy utility service, both electricity and gas, though they use gas only for cooking. When asked why he did not use gas for heating the house, the tenant answered that the gas cost money and there was plenty of wood on the place and he could cut the wood himself, putting into operation the old security law: "He who cuts his own wood is twice warmed."

INSTRUCTION VALUE OF WORK RECORDS

One of the conditions of the contract is for the tenant to keep a day by day record of his labor at the various tasks he performs. This record is extremely interesting. It shows that in the year 1938, basing his total record on a 6-day week, he worked but slightly in excess of 8 hr per day, 10.9 hr in 1939, and 10.5 hr in 1940. This includes every piece of work that could be charged against the operation of the farm. It includes chores of milking, feeding the chickens, plowing, cultivating, planting, harvesting, grading and packaging, selling, fertilizing, improvements or repairing, pasture improvements, and any miscellaneous labor. The distribution of his working hours is an extremely interesting thing, and I think that it would be essential that this be a compulsory part of every tenant farm contract. For instance, in 1938 only 226 hr were spent in plowing the soil, 161 hr in 1939, and 171 in 1940. Thus if it was possible to make the plowing of the ground completely automatic, he could have saved only 6 per cent of his total labor. Yet to have purchased a tractor and its accompanying tools would have more than quadrupled the total investment in team and farm equipment. Remember that this is a small farm, and for this area is an economic unit.

The labor record makes it possible for this farmer to analyze his operations, to see just where his time is going, and where he might try to reduce his time or improve his income with respect to time invested.

This type of contract in the operation of this farm, now having been in operation more than three years, has been followed as the basis for the satisfactory operation of many tenant farms other than this.

The tenant farm problem is now a problem of putting farmers to work so that they can produce and enjoy the benefits of their production. Furthermore, this type of farm does not further complicate the so-called surplus problems. I believe that when the job is done, it will be done by engineers; engineers who themselves are working; engineers who are thinking, analyzing, and acting on their analyses of the situation.

Sweet-Potato Storage House Construction

(Continued from page 222)

considerably, as well as lower the cost of construction and upkeep. Little light is admitted to the interior of a well-filled potato house by side windows, and a few electric lights will give better light at less cost.

A filled dirt floor can be built cheaper than a wooden floor, and will allow the humidity to be maintained much easier. Wetting down the floor about one week before curing begins and once or twice more during storage has been shown to supply sufficient moisture in the Clemson curing house to maintain the optimum uniform relative humidity for the entire period. There may be some loss or gain of heat from the dirt floor, depending upon the temperature differential between the interior of the house and the soil. Addition of a rigid insulation board in the center of the concrete foundation will reduce loss of heat through that part of the house.

Ducts for supplying air to the building should come from below, as side ventilators cause cold spots in the potatoes next to the openings. Tile ventilators have been used at Clemson with much success, as electric heaters can be mounted directly over them. If the heaters are running, the air will be heated before it is introduced into the storage house. Of course, all doors and ventilators should be weatherstripped.

A thermostat will aid greatly in maintaining a uniform temperature and relative humidity. From 0.37 to 0.55 kwhr of electricity were necessary to cure each bushel of potatoes in the curing house at Clemson in 1939, and a little more than one kilowatt-hour was necessary to cure each bushel in 1938. The greater quantity of electricity used in 1938 was undoubtedly due to the difference in temperature of the periods during which the roots were harvested. Harvesting began two weeks earlier and was performed during warmer weather in 1939 than in 1938. For the storing period from 1.74 to 2.72 kwhr of electricity were used in 1939-40 while 1.28 to 1.99 kwhr were used in 1938-39. This difference is principally due to the difference in temperature between the two seasons.

For the entire period, an average of 2.69 kwhr per bushel were necessary in 1939-40 and 2.73 kwhr per bushel were necessary in 1938-39. This house is small, the two rooms in the test containing 360 bu. Larger houses should require less electricity per bushel, as the exposure per bushel is much smaller.

SUMMARY

The prime purpose of curing sweet potatoes is to heal the wounds and to thicken the skin. These processes are greatly facilitated by the maintenance of temperatures between 80 to 85 F and relative humidities of 80 to 85 per cent.

The prime purpose of storing is to maintain life processes at a minimum, in order to promote long storage life. Temperatures of 50 to 55 F, combined with 80 to 85 per cent relative humidities are generally recognized as the proper conditions for this purpose.

Generally speaking, stoves fail to maintain desirable curing and storing temperatures uniformly throughout the storage house. Wide fluctuations in temperature and humidity promote excessive shrinking and rotting of the roots.

Experiments have shown that electric heaters maintain curing and storage temperatures uniformly throughout the storage house, reducing shrinking and rotting to a minimum.

The economical use of electricity in storage houses requires a type of construction which minimizes flow of heat through the walls.

An Economic Analysis of Large and Small Grinding Units for Dairy Farms

By I. P. Blauser
MEMBER A.S.A.E.

IN MAKING an economic analysis of small and large grinding units for dairy farms, it seems only logical that first we need to get a picture of the job to be done, and then consider possible methods for doing the job. After an analysis has been made of costs of the different methods of doing the grinding, and also giving consideration to local situations, individual farm conditions, present equipment, and the farmer's own likes and dislikes, a feed grinding program can be recommended with some degree of intelligence.

What are the grinding requirements for dairy cows? The average recommendation, by a large number of leading agricultural colleges, is to grind all grains to a medium coarse degree of fineness (Fineness Modulus, 2.80–3.60), and feed roughages whole. If we do not need to provide for roughage grinding on the dairy farm, requirements are somewhat simplified. Corn in the dairy ration may be shelled, or it may be in the ear. If shelled corn is used, then our problem is still further simplified. If the dairy farmer insists on using corn and cob meal, his selection of grinding equipment will be somewhat more limited. Selection of grinding equipment is influenced greatly by fineness of grinding.

In general, then, we know what needs to be ground and how fine. The next question we need to ask is how much is to be ground. Since I am more familiar with Ohio's conditions and requirements, I will use Ohio figures. They probably are not greatly different from those of a number of other states.

Our dairy specialists tell us that the average amount of grain fed per cow will be between 1500 and 2000 lb yearly, for average production. Feed summary records of the Ohio Dairy Improvement Association show that cows producing less than 200 lb of butterfat annually used 1653 lb of grain, while cows producing more than 400 lb annually used 3374 lb of grain. These variations need to be kept in mind when estimating feed grinding requirements for dairy cows on different farms.

Unless careful attention is given to the grinding methods, the cost of grinding may exceed the increased efficiency of the grain due to grinding. It has been said by dairy specialists that grinding increases the feeding value of grain only 10 per cent, which, if true, means that grinding grain, particularly when grain prices are low, must be done at minimum cost if the practice is to show a return.

How shall the grinding be done, so that the practice will be profitable? Feed grinders are available in a wide range of sizes from the small hand-power grinder to large custom mills. For the dairy farmer the hand-power grinder need not be considered, and units requiring larger than 5 or 7½-hp electric motors should not be considered for electrically operated grinders, because larger motors are not usually permitted on single-phase rural lines. Considered from the standpoint of the size of motor required to operate it, ½ to 1 hp represents a small grinding unit; 1½ to 3 hp, a medium unit, and 5 to 7½ hp, a large unit for electrically operated grinders. When comparing tractor-operated grinders, with electrically operated grinders, then the 5-hp size and less are considered small grinders.

Too often we may be inclined to consider only the power or operating cost, when considering different methods of doing the same job. Quite often the fixed or overhead charge is more important than operating cost. All of these costs must be taken into consideration if we are to get the total cost.

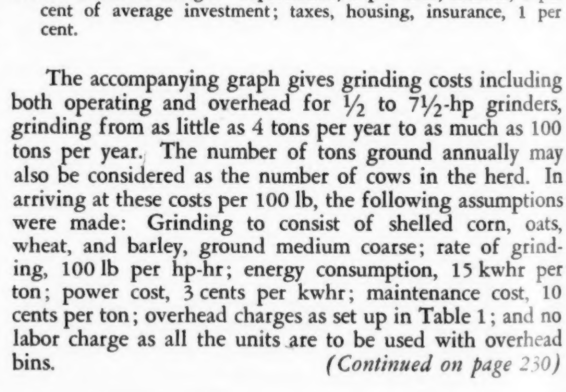
Table 1 gives the average cost and yearly overhead charges for grinders ranging in size from ½ to 7½ hp. These costs are for hammer type grinders. For burr type grinders the costs in some sizes would be somewhat less.

TABLE 1. COST AND YEARLY OVERHEAD CHARGES FOR COMPLETE GRINDING UNIT

Size of unit	½ hp	1 hp	2 hp	3 hp	5 hp	7½ hp
Cost, grinder and motor	$60	$100	$140	$180	$225	$325
Yearly overhead charge	$7.34	$12.24	$17.13	$22.03	$27.54	$39.78

NOTE: Overhead charges—depreciation, 8 per cent; interest, 6 per cent of average investment; taxes, housing, insurance, 1 per cent.

The accompanying graph gives grinding costs including both operating and overhead for ½ to 7½-hp grinders, grinding from as little as 4 tons per year to as much as 100 tons per year. The number of tons ground annually may also be considered as the number of cows in the herd. In arriving at these costs per 100 lb, the following assumptions were made: Grinding to consist of shelled corn, oats, wheat, and barley, ground medium coarse; rate of grinding, 100 lb per hp-hr; energy consumption, 15 kwhr per ton; power cost, 3 cents per kwhr; maintenance cost, 10 cents per ton; overhead charges as set up in Table 1; and no labor charge as all the units are to be used with overhead bins. *(Continued on page 230)*



A paper presented before the Rural Electric Division at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 5, 1940. Abridged. Author: Extension agricultural engineering specialist, Ohio State University.

Farm Mechanization in Southern Agriculture

By Harry G. Davis

EDITOR'S NOTE: This is posthumous publication (abridged) of an address delivered by Mr. Davis before a meeting of the Southern Section of the American Society of Agricultural Engineers at Atlanta, Ga., February 6, 1941. His untimely passing on February 22 leaves it as his final message to agricultural engineers. It sums up many of his observations on the relation of mechanical means to economic and social objectives. Its publication here, to make the most of its value as material for the information, consideration, and inspiration of present and future agricultural engineers, seems a fitting tribute to the author's belief in and contributions to the conservation of human values. Mr. Davis was director of research for the Farm Equipment Institute and a member of A.S.A.E.

IT IS quite generally recognized that southern agriculture is going through a period of revolution. New crops are being introduced, new cropping systems are being employed, great strides are being made in the control of erosion, and soil fertility is being built up and maintained. All of these are fundamental to a successful agriculture anywhere, and the fact they are now receiving so much attention promises much good for the future of your agriculture.

Of all the present trends in southern agriculture, the one which holds the greatest promise for the future, in my opinion, is the trend toward a still greater use of mechanical equipment. In fact, your whole agricultural program, if I understand it correctly, is predicated largely upon farm practices which will require a greater use of power and machinery. By the term "power", I do not mean exclusively the use of tractors, but also the use of work animals in units large enough to perform satisfactorily the heavier jobs required in these new practices.

BALANCE IN PROGRESS OF WORK EFFECTIVENESS

An ever-present problem in this country during its transition from an agricultural nation, with 80 per cent of its working population engaged in farm work, to an industrial one where most of its workers are occupied in nonagricultural pursuits, has been to maintain a balance between the various groups which comprise our economic commonwealth, particularly groups which produce the commodities of commerce. Taken as a whole, we have done a pretty good job of maintaining this balance, although some groups have lagged behind and now find themselves at a temporary economic disadvantage.

Our progress from an agricultural to an industrial nation was not accomplished by a broad, simultaneous advance on all lines of our economic endeavor, but rather by sorties, or thrusts, by certain groups which forged ahead, gained, and consolidated advanced positions, and held them until the other groups caught up. This method of progress meant that there always were some groups occupying advanced positions which gave them a temporary advantage.

In the final analysis, the economic position of any group, or individual, is controlled by its operating efficiency. It is based on the fundamental principle that man's material welfare is governed mainly by the volume of goods he can produce or the quality of the services he can render to his fellow men. The more goods or the better services he can supply, the greater will be his rewards. This is the only basis upon which any group or individual can hope permanently to improve its economic position. Other expedients may be tried but they are all bound, in the end, to fail.

With this fundamental principle in mind, let us see how well the balance between the efficiency of agricultural and factory labor has been maintained during the period when production methods both on the farm and in the factory were being revolutionized by the technology of mechanization. Have farmers been able to keep pace with the changing conditions in other industries, or have they been handicapped by the increasing efficiency of labor in factories whose products they buy? Are they now able to exchange the products of their own labor for those of the factory worker on an equitable basis?

In 1849, which was before mechanization had influenced the productive efficiency of workers in any group to any great extent, it required about 2,800 hr of man labor on the farm to produce 1,000 bu of wheat, and about the same number of man-hours to produce $1,000 worth of factory products. History records no complaints of maladjustment in those days, and probably it is fair to assume that there was then a fairly well-adjusted balance in the relative efficiency of agricultural and factory labor.

Important technological changes in production methods in American factories began developing during the later years of the nineteenth century. The efficiency of factory labor, as measured by the value of products produced per worker, increased about 200 per cent between 1849 and the 1910-14 period. That meant that farmers in the 1910-14 period had to deliver about 300 units of their products, at the same unit price, for each 100 units required in 1849 to buy the output of a factory worker. How did this change affect farmers? Was balance with factory labor destroyed?

Coincident with the adoption of newer technologies in manufacturing industries, agriculture also turned to the use of production equipment and made a corresponding increase in its own labor efficiency. While it did require three times as many units of products to buy the annual output of a factory worker in the 1910-14 period as it did in 1849, a farmer could produce this larger requirement with less labor. For instance, the labor required to produce 1,000 bu of wheat came down from about 2,800 man-hours in 1849 to 440 in the 1910-14 period, which meant that 3,000 bu could be produced in 1,320 hr, as compared with 2,800 hr for 1,000 bu in 1849. Likewise, 1,000 bu of corn in 1849 required 840 man-hours; in the 1910-14 period, 3,000 bu required only 516 hours.

Also, there is no record of complaints of maladjustment in the relative efficiency of farm and factory labor in the 1910-14 period. As a matter of fact, that era is now considered as a parity period.

VARIATION BETWEEN FARMERS IN MAINTAINING BALANCE

Now what about the next 25 years, or from 1915 to date? Did we continue to maintain the balance between the efficiency of farm and factory labor? The answer is "yes" and "no". It is "yes" for those farmers who have made use of the labor-saving machinery that was available, and "no" for those who have not.

In 1939, according to the U. S. Department of Commerce, the value of factory products averaged a little over $7,200 per wage earner per year, or about double what it was in the 1910-14 period. In 1939, a farmer had to deliver 200 units of his products, at the same unit price, for each 100 units required to buy the annual output of a factory worker in the 1910-14 period. What effect did this change have on the relative efficiency of farm and factory labor?

Taking wheat again as an example, we find that by the newer production practices now in use on hundreds of

Small tractors and their operated equipment fit in with the new southern agriculture of diversified cropping, livestock raising, soil building, and use of less but more highly-skilled labor. They fit the climate, the hills, small farms, small fields, small pocketbooks, and small equipment habits of much of the South. They show promise of complementing and easing the strain of growing industrial development in many southern cities

thousands of farms, it required only 165 man-hours to grow 1,000 bu of wheat, as compared with 440 man-hours by the methods which were most efficient and most commonly used in the 1910-14 period. By using these newer methods, 2,000 bu of wheat could be produced with 330 hr of labor, or one-third fewer hours than was required to produce 1,000 bu by the most efficient methods in common use 25 years ago.

Thus, so far as relative labor efficiency is concerned, farmers have kept pace with factory workers. According to the report of the National Resources Committee, published in June 1937, the output per worker increased 39 per cent between 1910 and 1930 in manufacturing industries, while the output per worker in agriculture increased 41 per cent.

But all farmers are not in that position. Many are still working with 1910-14 methods instead of using the modern labor-saving equipment which is now available. About half of the wheat and more than 80 per cent of the oats grown in the United States in 1938 was harvested by the binder-thresher method instead of with combines. However, farmers who have made use of the available labor-saving machinery are away ahead of factory workers in their relative efficiency. Those who have not, of course, have lagged behind and now find themselves at a considerable disadvantage in trading their own for factory labor.

The more I study the question, the more I am intrigued with the thought that greater efficiency in the use of production labor will do more to improve the economic status of farmers, and to increase national prosperity, than any other thing that could take place in agriculture.

In effect, increased labor efficiency goes a great deal further than most of us can visualize. It means more units of production per man employed, resulting in greater labor income for operator and family workers, and higher wages for hired hands. All this means more buying power and greater consumption of the products of other workers. It also means larger sales in local stores and more local enterprises which directly serve the farm population. Added to all these, it means increased employment.

The importance of more efficient use of productive labor on the farm can be more clearly recognized when we remember that this nation's industrial development was predicated upon increased efficiency of farm labor, which enabled a smaller proportion of our working population to produce our food and clothing material, thus releasing millions of others that they might be free to engage in the many new industries which transformed this from an agricultural to an industrial nation. Without the emancipation of millions from the necessity of producing food and fiber, the manpower required to operate the new industries would not have been available.

George Washington laid down what seems to me to be the fundamental principle which governs this whole subject of greater labor efficiency. He said: "The aim of farmers in this country is not to make so much from land, which is or has been cheap, but from labor, which is dear."

In 1938, the 910 farmers in the south central states, who reported on their operations to the U. S. Bureau of Agricultural Economics, spent 23.5 per cent of their total receipts for hired labor. In addition, they and members of their families contributed labor which had a value equal to 27.7 per cent of their cash income. In the east north central states, where there is a higher degree of mechanization and the type of farming is somewhat different, expenditures for hired labor amounted to only 10.4 per cent of the receipts of the reporting farmers, while the value of labor performed by operators and members of their families had a value equal to 31.5 per cent of their receipts.

These, I think, are most significant figures and seem to show great possibilities of increased profits for farmers through the extended use of production equipment. The total value of the labor used by these farmers in the south central states was equal to 51.2 per cent of their total receipts in 1938, of which about 46 per cent had to be paid out to hired hands, while the labor used by the east north central farmers was equal to only 41.9 per cent of their receipts, 75 per cent of which was for family labor and only 25 per cent was out-of-pocket expense for hired hands.

The figures which I have just cited not only show that machine methods greatly reduce the amount of labor required in crop production and other farm operations, but also that it makes it possible for the operators and the members of their families to perform a greater proportion of that labor. In other words, mechanization more firmly establishes the family-operated farm.

I fully realize that southern farmers, until recently, have not been able to turn as readily to mechanization as have those in other sections of the country. This has been due, principally, to the cropping systems employed. Two of

their principal crops, cotton and tobacco, do not lend themselves to complete machine methods of production, and, incidentally, these are crops which require a large amount of labor. So long as these crops predominated, the need for man labor at certain seasons of the year, such as harvesting time, made it desirable to provide employment the rest of the year so that the help would be available when needed. Thus mechanization of such operations as could have been performed by machines was retarded. This situation apparently is being changed by the new cropping systems being adopted by thousands of farmers.

The newer system provides for curtailing acreages of high-labor crops and substituting others which do not require so much labor, thereby getting a better balance between man-hours worked and total marketable production of the farm. The importance of this far-reaching program cannot be overemphasized. Its advantages are many. Among these might be mentioned the better utilization of productive labor, with more salable output per hour worked, and the reduction of hazard of disaster resulting from total crop failures or ruinous prices, always a threat to the one-crop farmer. In other words, it will stop the old practice of "putting all the eggs in one basket."

The size of an agricultural community, no matter where it is located, is not measured by square miles nor by the number of farms in it, but by the volume of income produced by its farmers. If its farmers are in the high income class, they will have more money to spend and business in town will be good; if they are in the low income group, there will be little money to be spent and business in town will be poor. That is why local business and professional men in the South should be 100 per cent for the far-reaching program of diversified production.

SOCIAL IMPLICATIONS OF FARM MECHANIZATION

There are some people who question the wisdom of this program and forecast undesirable social impacts which might result from displacement of farm workers by mechanization in the South. Frankly I cannot agree with them. Men of my age have personally witnessed the so-called industrial revolution, as machines supplanted hand methods in production, and have noted that whatever maladjustments did occur were only temporary, and that the continuing trend has been toward a broader and fuller life and a higher standard of living for everybody. A submerged agriculture, where the spendable income is not sufficient to support a decent standard of living, certainly is not a national social asset and its continuation should not be tolerated. There may be some temporary problems presented through its elimination, but the ultimate result will be a higher standard of living for everybody.

One effect of increased efficiency of farm labor here in the South will be to bring the proportion of agricultural and nonagricultural workers closer to the national average. At present you have about 380 persons per 1,000 population gainfully employed, of whom 150 are in agriculture and 230 in other occupations. That is about what the national average was in the 1910-14 period, when the value of a factory worker's annual production was about one-half what it is now. The present national average is about 395 per 1,000 population gainfully employed, of whom 85 are in agriculture and 310 in other occupations.

As the income and buying power of farm workers increase through the use of machine methods of production, and new farm management methods, you can reasonably expect a substantial increase in employment in local towns and cities, which will absorb some of those being freed from farm work. You can also expect the wonderful expansion in manufacturing, now going on here in the South, to absorb many people who are now at work on farms. All of this, I am confident, will result in a better balance among the various groups of workers which will result in greater prosperity than the South has witnessed in many decades.

Discussion by James L. Shepherd[1]

JUNIOR MEMBER A.S.A.E.

WE ARE sufficiently agreed as to factors which have prompted this somewhat sudden trend to machinery in southern agriculture. Of primary concern to us now are factors which will have fundamental bearing on future trends. We may find the information which we are looking for in the answers to two important questions: (1) Is present farm machinery justifying its cost in the eyes of the farmers? (2) Is the farmer receiving the information necessary for greatest economy in the selection and operation of his equipment?

Of 227 tractor-minded Georgia farmers representing 66 counties and a total of 59,000 acres of cultivated land, a recent survey showed that 174 were using 214 tractors and tractor equipment. Tractors were being used in cultivating individual farms from 50 to more than 1200 acres. All 174 tractor operators were pleased with the results of their change from animal to tractor power. Not one would consider a return to old methods. Figures such as these speak for themselves, and while there are probably exceptions and some dissatisfied farm machinery users in the South, we would consider these figures to be somewhat representative of the present popularity of tractors and equipment in this territory, which has been recognized as the last to accept modern machinery.

We cannot overlook the urgent need of southern farmers for knowledge of at least the fundamental considerations in the selection, operation, care, and repair of machinery which is in operation or being considered. Agencies now engaged in this instruction are far from adequate. It should be the desire of every agricultural engineer, and other agricultural workers as well, to participate to the limit of their capacity toward rendering to southern agriculture this service, which may determine the balance between success and failure of farm mechanization in a wide practical application. In order to make available instruction which every present or probable machinery user should have, it would not be necessary that the methods used by public agencies be materially changed. However, wherever practicable, emphasis should be directed to this phase of assistance to the farmer. In practically all cases, present machinery operators are seeking information additional to what they have, because they know that it influences the amount to be realized from their investments. They learn through experience that, to operate machinery most economically, they must have a knowledge of all the factors which affect its characteristics of performance.

I consider that the most effective means of teaching farmers the intricacies and factors of machinery application is that of short courses, in addition to courses of instruction in vocational training departments. Through short courses made available in Georgia during the past two months, more than two hundred farmers have received valuable instruction in the fundamental considerations which are so essential for successful operation of machinery. This method employs the services of a number of experts in machinery phases including the selection of machinery to suit the duties required; the operation, care, and repair of

[1]Mr. Shepherd is assistant professor of agricultural engineering, University of Georgia.

machinery, with emphasis on the tractor; and operation and care of rubber tires in farming applications. Demonstrations of items of equipment in performing as many operations in the farming cycle as the season permits, are effective in the short course. It is necessary, for a course of instruction of this type, that all available sources of assistance be utilized. Farm machinery manufacturers are prepared to offer assistance in the form of demonstrations and instruction on their lines.

In our efforts to understand the significance of the trend toward mechanization in southern agriculture, let us not lose sight of the concern that must be exercised to hold to a minimum the amount of money which may be wasted through a lack of the knowledge so imperative for the most advantageous employment of machinery in farming operations.

An Economic Analysis of Large and Small Grinding Units for Dairy Farms

(Continued from page 226)

From the graph it can be seen that when only 4 tons are ground annually the cost varies from 11.92 cents per 100 lb for the 1/2-hp unit to 52.25 cents per 100 lb for the 7 1/2-hp unit. If as much as 25 tons are ground annually, the cost of grinding ranges from 4.22 cents for a 1/2-hp unit to 10.70 cents per 100 lb for the 7 1/2-hp unit. For 100 tons annually, the cost is 3.11 cents per 100 lb for the 1/2-hp unit, and 4.74 cents for the 7 1/2-hp unit. Grinding time needs to be considered, and for that reason the practical limit for the 1/2-hp unit may be 50 tons annually, requiring approximately 2 3/4 hr operation daily; for the 1-hp unit, 75 tons; and for the 2-hp unit, 100 tons. If longer daily grinding periods are not objectionable, then the maximum limit can be raised and lower cost realized. The lower limit is set by charges for competitive methods of grinding.

There are other means of grinding feed for dairy cows, which need to be given consideration. Some years ago, before electric service was common, the common method was to grind feed on the farm with tractor power, or haul it to a custom mill to be ground. A charge of 15 to 20 cents per 100 lb was usual.

Grinders for tractor operation will cost from $50 to $200, depending upon the type of grinder, with annual overhead charges ranging from $6.12 to $24.48. To these costs must be added the operating costs, which include maintenance, labor, and power. Operating costs for tractor grinding are about the same as for electric power.

In Ohio some portable grinders go from farm to farm, doing the grinding at the farm and charging only from 8 to 10 cents per 100 lb. Some of the custom mills are competing with the portable grinders by sending a truck out to pick up the grain to be ground at the mill and then delivering it back to the farm at the same prices charged by the portable grinders.

With these methods also in the grinding picture, at least in Ohio, the problem is not always one of selecting a large or a small grinder, but quite often the selection of a method.

Selection of proper feed grinding methods and equipment can often make feed grinding on the farm a profitable operation. Some farms may use such a small amount of ground feed that operating even the smallest grinder may cost more than custom grinding. Few dairy farms in Ohio will need larger than a 3-hp unit, unless they use corn and cob meal in the ration.

Activities in Fire Prevention and Protection

By Henry Giese
MEMBER A.S.A.E.

FIRE WASTE exacts a toll of millions of dollars annually from American farmers. Notwithstanding the common statement that the "loss was fully covered by insurance," the individual is usually not only the heaviest loser, but the one least able to stand the loss. Life savings all too often fade out of sight with the smoke. Nor does any analysis of economic waste give an adequate picture of the true situation. Many lives are lost and still more persons are injured. People are left temporarily homeless and deprived of the use of buildings necessary for successful farm operation.

The problem is more serious in rural areas than in urban centers. Most city fires are detected early, and being within easy range of fire fighting equipment, are extinguished with little actual damage. Rural fires frequently get a good start before being detected, and because of the distance separating them from fire-fighting equipment, usually burn to exhaustion.

An analysis of more than twenty thousand rural fires in Iowa covering a ten-year period shows that, where the cause can be identified, a relatively few preventible causes are responsible for a large percentage of our fire waste.

Preventive measures offer the greatest possibilities for reduction of fire waste in rural areas. Prevention, an engineering problem, requires first, a systematic study of the factors involved and, second, a program of education and inspection.

The two national organizations to which the American Society of Agricultural Engineers has representatives, are working on the research and publicity phases of this important subject.

In a pamphlet entitled, "The Story of the National Fire Protection Association," the aims and activities are summarized as follows: "The National Fire Protection Association is the clearing house for all that is authoritative on the subject of fire waste, fire protection, and fire prevention. It is a noncommercial and nonprofit-making organization supported by regional organizations, and approximately four thousand individuals, firms, and corporations. Membership is open to any individual or organization interested in the protection of life and property against loss by fire. The membership is widely distributed among men and companies of varying interest.

"The National Fire Protection Association has two functions: One is to make the standards under guidance of which the fire waste may be checked; the other is to educate the people in the observance of these standards and point out the grievous economic penalties for ignoring them."

The activities in general comprise (1) research resulting in the preparation of standards, (2) a field service for the benefit of local committees and other interested parties, (3) a program of public education, and (4) numerous technical publications.

While most agricultural engineers have interests in the work of a number of these forty some committees of the Association, we are especially *(Continued on page 238)*

A report of the A.S.A.E. representative to the National Fire Protection Association and National Fire Waste Council. Presented before the Farm Structures Division at the annual meeting of the American Society of Agricultural Engineers at State College, Pa., June 19, 1940. Abridged. The author is professor of agricultural engineering, Iowa State College.

NEWS

Washington Section Installs Officers

NEW OFFICERS of the Washington, D. C. Section of the A.S.A.E., who took office at the close of the meeting of May 14, are R. B. Gray, chairman; L. A. Jones, vice-chairman; and Miss Mary F. Taylor, secretary.

Brig. Gen. J. K. Crain, Ordnance Department, U. S. Army, was guest speaker at the meeting. He spoke on the work and progress of the Department. Fifty members and guests of the Section attended the meeting, which was a noon luncheon.

National Congress on Surveying and Mapping

A National Congress on Surveying and Mapping is to be held in Washington, D. C., June 16-18. It has been planned in response to a demand growing out of increased surveying, mapping, and map using activities by federal, state, county, city, and private practitioners in connection with public works, defense, and industrial activities.

At the opening session the federal surveying and mapping program is to be presented, and formally discussed by representatives of the map users and map makers viewpoints.

The second session will be devoted to cooperative efforts of professional surveyors on a state-wide basis; county surveyors and county maps; and city surveys.

Subjects scheduled for the second day include military mapping, mapping and surveying of military reservations, surveying and mapping education, use of aerial surveys in topographic mapping, control surveys, state-wide plane coordinate systems, and the military grid coordinate system.

A business session and trips to governmental surveying and mapping offices and other points of interest in the Capitol are on the program for the third and final day.

Sponsoring organizations include the Committee on Surveying and Geodesy of the Society for the Promotion of Engineering Education, the Surveying and Mapping Division of the American Society of Civil Engineers, the American Society of Photogrammetry, and the Federal Board of Surveys and Maps. All interested persons are invited to attend. Sessions will be held in the Department of Commerce Building.

Safety Short Course in Purdue Summer Session

SAFETY in the home, school, industry, recreation, and on farms and highways, as a matter of useful information to be worked into various courses in public schools, will be emphasized in a three-week summer session course at Purdue University, June 16 to July 3.

Announced as a "Safety Education and Driver Training Workshop," the course is planned to help teachers meet the requirements for safety instruction in the schools of Indiana established by the state board of education. Exhibits, reference materials, teaching aids, conferences, and cooperation between those enrolled will be the means of helping teachers solve their individual and group problems as to what to teach public school pupils in the matter of safety, and how to teach it. Three hours of graduate or undergraduate credit will be given for the course.

Two specialists from the Center for Safety Education, New York University, and eight members of the faculty of Purdue University with experience in public safety from home, recreational, and vocational standpoints, will constitute the staff for the course. I. D. Mayer, of the agricultural engineering department, will be one of the staff members.

Heating and Ventilating Engineers Meet

TIMED to coincide with the opening of the Pacific Heating and Air Conditioning Exposition there, the semiannual meeting of the American Society of Heating and Ventilating Engineers will be held at San Francisco, June 16-20.

Subjects scheduled for consideration in the technical program include panel heating and cooling, weather data for cooling design, conservation of underground water, the thermal conductivity of wood, effect of insulation, the interaction constant for moist air, analysis of factors influencing building heat losses, and effect of local cooling on reactions of individuals. A.S.A.E. members who may find it convenient are invited to attend.

A.S.A.E. Meetings Calendar

June 23-26—Annual Meeting, Knoxville, Tenn.

Sept. 29-Oct. 1—North Atlantic Section, Jackson's Mills, W. Va.

December 1-3—Fall Meeting, Stevens Hotel, Chicago.

Fowler McCormick Promoted

AT A recent meeting of the board of directors of the International Harvester Company, Fowler McCormick (Member A.S.A.E.) was elected president of the company, effective May 15, succeeding Sydney G. McAllister, who was advanced to fill a vacancy in the chairmanship of the Executive Committee.

Mr. McCormick began his career in the company in 1924, as a shop student. He was transferred to the engineering, manufacturing, and sales departments in the process of increasing his familiarity with the company's products and business. In 1929 he was made branch manager at Grand Island, Nebraska. The following year he was called to Chicago as district sales manager for the Northwest District, from which he was promoted to assistant manager of domestic sales in 1933.

In 1934 he was elected a vice-president and placed in charge of foreign sales, being continued in that work from 1935 to 1938 as second vice-president of the company. From that work he was transferred to charge of all of the company's manufacturing operations, in the same vice-presidential capacity, continuing there until his current promotion.

Southern Chemurgists to Confer at Nashville

A FIRST annual Southern Chemurgic Conference will be held at the Hermitage Hotel, Nashville, Tenn., June 17, 18, and 19. Southern chemurgic crops and industries developing to process agricultural materials are emphasized in the program.

A.S.A.E. members Wheeler McMillen and L. F. Livingston are luncheon and general session speakers, and Arnold P. Yerkes will preside at the morning session of June 19. Interested members of the A.S.A.E. will be welcome to attend, and may find it convenient to do so as part of their trip to attend the A.S.A.E. annual meeting in Knoxville the following week.

Hydrology Conference

AGRICULTURAL hydrology is included for brief consideration in the program for an Hydrology Conference to be held at State College, Pa., June 30 to July 2.

C. E. Ramser is scheduled for a paper on "Applications of Hydrology to Soil and Water Conservation." H. S. Riesbol will discuss "Some Aspects of Subsurface Water in Hydrologic Research on Agricultural Watersheds."

Weather, hydrographs, infiltration, forest influences, snow runoff, droughts, evaporation and transportation from natural surfaces; and applications to urban areas, flood control, transportation, water power, and the third locks of the Panama Canal are other subjects to be presented and discussed.

Personals

John M. Ferguson and E. L. Barger are two of the writers of Kansas Extension Mimeograph Circular 37 on "Lister Adjustment for Sorghums."

E. L. Hansen has accepted a position as agricultural engineer with the Portland Cement Association, Chicago, having resigned as extension agricultural engineer at the University of Illinois. Mr. Hansen has been in agricultural engineering extension work at the University of Illinois since 1936. In addition to his extension activities, he has been taking graduate work and will receive a master's degree in civil engineering this month. As a result of soil stabilization research which he did for graduate study, he was recently elected a member of the Illinois chapter of Sigma Xi.

An Appreciation of Colonel Zimmerman

OLIVER BRUNNER ZIMMERMAN passed away at Edward Hines Hospital, Hines, Ill., May 10, after more than half a year of convalescence in a game fight to regain his health. As a past-president, honorary member, McCormick medalist, and active worker in the American Society of Agricultural Engineers, and a man all of its older members knew, and were proud to know as a friend, his loss will be deeply felt among engineers.

OLIVER BRUNNER ZIMMERMAN

Biographical highlights of the events, interests, and achievement of his life, with some tribute to his character and abilities, have been published previously, in connection with some of the various honors bestowed upon him, but his passing reemphasizes their significance. (AGRICULTURAL ENGINEERING for August 1934, June 1935, and February 1940).

His high school record earned him a scholarship at the University of Wisconsin. There he obtained his bachelor's degree in mechanical engineering, in 1896, and with four more years of study "in absentia," the professional M.E. degree in 1900. But that was only the beginning which developed scholarly habits and interests to be continued throughout his life. Some of the other subjects he studied from time to time, not for credit but as matters of personal interest and information, were physical chemistry, personal efficiency, modern business, and art. His approach to life, and to the technical problems of his work, was scholarly. His professional reports and other technical writings reflected a scholastic interest projected to practical application and usefulness.

In science, the principal field of his scholarship, Colonel Zimmerman's contributions were largely the result of basing his approach to the practical problems of his work, on the fundamental science involved. His scientific interests and accomplishments, evident throughout his life, are specifically attested in his activity as a corresponding member of the Wisconsin Academy of Science, Arts, and Letters; and by the Pennsylvania Military College conferring on him, in 1919, the honorary degree of Doctor of Science, in recognition of his war and scientific works.

Supporting the development of his mind with parallel development of the body, in university athletics he was a track man. Moreover, he was a fair, hard-fighting, clean-living, true sportsman in the finest sense of the word and in all competitive aspects of life. His small stature and mild manner were more than counterbalanced by a physical stamina that carried him successfully through many a strenuous work emergency, and an occasional problem of personal self-defense.

The schools in which he developed as a scholar called him as a teacher, and his scholarship proved infectious. But while progressing from high school teaching and volunteer athletic coaching to an assistant professorship on the University of Wisconsin graduate faculty, he began thinking more and more of engineering as a matter of industrial practice. Summer vacations in industrial work weaned him gradually away from the classroom and won him completely in 1905. Between 1900 and 1921 he declined more than a dozen attractive offers of college teaching, research, and administrative positions, to fulfill his obligations to his current employers and to continue the new and unfinished business he saw for scholars, scientists, and teachers in industry.

Professionally Colonel Zimmerman developed first and continually as a mechanical engineer. However, his first work after leaving college teaching introduced him to farm machinery as a field of application for his mechanical engineering training. It turned out that this was henceforth to be his major engineering interest, and led to his additional development as an agricultural and automotive engineer.

Not a professional soldier, the occasion of war and his own patriotism combined to make him primarily a military engineer from early 1917 through part of 1919, just as he was beginning to reach his prime as a mechanical, agricultural, and automotive engineer.

One of the first civilian engineers taken into the expanding army at that time, he was commissioned a captain and detailed to duty at the General Engineer Depot, Washington, D. C. There he was assigned to head the Mechanical-Civil Equipment Division, in charge of selection, purchase, and redesign activities on engineer equipment for the U. S. Mobile Army and Coast Defense. After a few months he was promoted to the rank of Major. Later he was transferred to duty as head of the research and development division of the same headquarters.

During much of his army service he was also liaison officer between the General Engineer Depot and the Bureau of Standards, a member of the staff of the Bureau of Standards, a member of the Board of Review of the General Engineer Depot, a member of the National Screw Thread Commission, and authorized historian of the development of the General Engineer Depot and its activities.

To summarize his war service, the army recognized and made the most of his capacity to direct the accomplishment of difficult, varied, and highly important engineering work; and he applied himself beyond the limits of ordinary physical and mental endurance to the responsibilities thrust upon him.

Proceedings for his promotion to the rank of lieutenant-colonel were stopped by the Armistice, but he was commissioned in that rank in the Engineer-Reserve in 1924 and assigned to Headquarters Sixth Corps Area until 1934, when he was transferred to the unassigned list at his own request, due to the pressure of his civilian work.

Resuming his civilian engineering career after the war, in the engineering and experimental department of the International Harvester Company, Colonel Zimmerman became a part of a swift panorama of farm machine history. The demand for farm machinery for high-capacity production to capitalize on high prices for farm commodities, changed to a demand for low-cost, high-efficiency equipment to lower costs of farm production and enable farmers to stay in business in spite of low prices. Mechanical engineering in the design and manufacture of farm tractors became inseparably related to automotive engineering, and the two tied in closely with the agricultural engineering of farm power, equipment use, and farm operating economy considerations.

Standards, specifications, materials, fuels, design, research, testing, demonstrations, and similar matters within his company, in its relations with other technical organizations, and in their larger significance as items of engineering progress in service to humanity, became the Colonel's well-known field of intensive activity.

As an author he wrote, not for the sake of writing, but as a means of recording and advancing professional progress; a means of making new ideas and information available to others, and of bringing the abilities of many to bear on significant engineering problems. At least ten papers by him as sole or joint author recorded in AGRICULTURAL ENGINEERING reflect his ability and extend to future generations the opportunity of some contact with his mind.

While not primarily an inventor, it is natural that his originality, thoroughly grounded in science and applied to problems of mechanical design, did result in a number of inventions of considerable value.

Becoming a member of the A.S.A.E. in 1920, he promptly began lending a hand in committee work, discussions, and other matters wherever his training and experience might be of value. His proven effectiveness in committee work, his active participation in meetings of the Society, and his evident broad background, vision, and other qualities were recognized by his election as first vice-president (1925-26); president (1927-28); honorary member in 1935; and McCormick medalist in 1940.

He served for several years as chairman of the Committee on Medals and Awards. In this he rendered important service in familiarizing the donors of the Cyrus Hall McCormick and John Deere gold medals with the nature and significance of agricultural engineering work, and the desirability of encouraging it with suitable recognition for distinguished achievement. His active interest in the establishment of these honors, in their award to other agricultural engineers, and in their significance to the future progress of agricultural engineering, for many years precluded recognition in this manner of his own distin- (Continued on page 234)

An Appreciation of Colonel Zimmerman

(Continued from page 232)

guished achievements. When this finally was possible, it became, appropriately, the crowning honor of his lifetime.

At the time of his passing he was also a member of the American Society of Mechanical Engineers, a life member of the Society of Automotive Engineers, and a corresponding member of the Wisconsin Academy of Science, Arts, and Letters. He had also held membership or served as company or organization representative in more than a dozen other technical organizations at various stages in the progression of his work and interests.

Notwithstanding the fullness of his life in his technology, he also lived beyond it in the realm of the richer spiritual and social life to which it contributes. Married, the father of four children, a member of the Unitarian Church, the A.F. & A.M., the Scottish Rite, the Shrine, American Legion, Reserve Officers Association, and of other nontechnical organizations at various times, he lived in first-hand contact with people and the human objectives which engineering helps bring to realization.

In June 1940, when he attended the annual meeting of the A.S.A.E. at Pennsylvania State College, and received the McCormick Medal, he was in poor health and beset with personal problems, but nevertheless keenly interested in the continued progress of agricultural engineering and the Society, in national defense and other affairs of the day, and in his business plans and ventures.

Shortly thereafter he entered Edward Hines Hospital for treatment in the hope of improving his health. His months there were marked by a series of gains, relapses, and new complications. Throughout this period he never seemed to lose interest in agricultural engineering or the hope of soon being able to return to active work.

Gentleman, churchman, engineer, scientist, scholar, teacher, athlete, sportsman, soldier, husband, father, clubman, organizer, executive, fraternalist, author, inventor, and friend—in versatility Colonel Zimmerman was a modern daVinci. Fate often treated him roughly, but as with the forging of fine steel, hard blows only served to emphasize his finer qualities. Destiny used him to contribute, in his own time and manner, to the progress of humanity, alternately rewarding him with the satisfactions of service and urging him on with visions of important work still to be done. Without being spectacular or popularly renowned, he was great in ways which engineers, scientists, and other close associates could best appreciate.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the May issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Donald H. Anderson, sales promotion manager, Aermotor Company, 2500 Roosevelt Road, Chicago, Ill. (Mail) 6438 N. Whipple St.

Bernard F. Berry, junior engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Luna Star Route, West Monroe, La.

A. H. Hemker, rural electrification representative, General Electric Co., Schenectady, N. Y. (Mail) 1130 South Country Club Drive.

Elmer W. Henry, engineer, The Massey-Harris Co., Racine, Wis. (Mail) 1116 13th St.

Keith H. Hinchcliff, instructor, agricultural engineering department, University of Arkansas, Fayetteville, Ark. (Mail) 522 Storer St.

Clarence N. Johnston, assistant irrigation engineer, irrigation division, University of California, Davis, Calif.

Ludy M. Massie, junior agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) RR No. 2, Hooker, Okla.

John L. Schmidt, student, rural electrification department, Westinghouse Elec. & Mfg. Co., 306 4th Ave., Pittsburgh, Pa.

Roger M. Smith, trainee, Caterpillar Tractor Co. (Mail) RR No. 1, Lawrenceville, Ill.

Joe M. Strasser, supervisor of sales research, International Harvester Co., 180 N. Michigan Ave., Chicago, Ill.

Chester W. Thompson, engineering trainee, Caterpillar Tractor Co., Peoria, Ill. (Mail) 312 E. Arcadia Ave.

James R. Turner, RR No. 1, Box 94, Fowler, Calif.

Mario Villa, agronomist, Caja de Credito Agrario, Industrial y Minero, Bogota, Colombia, S. A.

TRANSFER OF GRADE

Roy L. Hauger, project engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Box 194, Pleasanton, Tex. (Junior to Member)

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, assistant chief, Office of Experiment Stations, U. S. Department of Agriculture. Copies of publications reviewed may be procured only from the publishers at the addresses indicated.

NATURAL WATER LOSS IN SELECTED DRAINAGE BASINS, *G. R. Williams et al.* (Coop. U.S.D.A. et al.) U. S. Geol. Survey, Water-Supply Paper 846 (1940), pp, IV+62, pls. 2, figs. 5 This report is primarily a statistical study that presents the results of computations of annual water loss, or annual rainfall minus annual runoff, for river basins in the humid or semiarid regions east of the Rocky Mountains. The basic period for which the computations are made is the water year ended September 30. As it was impracticable to present all the basic data used, only sample computations are given. The various steps in the computations and the probable accuracy of the results are discussed.

POWER ALCOHOL FROM FARM PRODUCTS: ITS CHEMISTRY, ENGINEERING, AND ECONOMICS, *G. Shepherd, W. K. McPherson, L. T. Brown, and R. M. Hixon.* Contrib. Iowa Corn Res. Inst. (Iowa Sta., Ames), 1 (1940), No. 3, pp. [1]+283-375, figs. 17. In nontechnical terms this bulletin summarizes the chemistry of gasoline as obtained by direct distillation and by cracking and polymerization processes; the engineering aspects of gasoline motor fuels; manufacturing processes for ethyl alcohol as made from various agricultural surpluses and wastes, including denaturation of the product for motor-fuel mixtures; economic considerations affecting the manufacture of fuel mixtures of alcohol with gasoline, with and without the further addition of tetraethyl lead; present and future problems, with which is included some discussion of petroleum conservation; and corn as an important raw material for alcohol manufacture. Four appendixes supplement the text discussion of some of these topics.

Alcohol may be made profitably for fuel blending purposes at approximately 25 cents per gallon and can be used in proportions of from 5 to 12 per cent with an increase in the price per gallon of between 0.7 and 1.2 cents over gasoline given an equal antiknock value or "octane" rate by other antiknock agents. It somewhat increases the mileage per gallon and lowers the operating temperature of engines. Its use is at present prevented by economic factors, but it may be brought into use by lowered cost of manufacture or by necessity for petroleum conservation.

AGRICULTURAL ENGINEERING INVESTIGATIONS AT THE WISCONSIN STATION, Wisconsin Sta. (Madison) Bul. 450 (1940), pp. 64-68, figs. 3. Forage harvesters which speed up grass silage making have been tested by F. W. Duffee, a home-made electric brooder has been improved by H. D. Bruhn, and windrowing before combining studied by Duffee.

AGRICULTURAL ENGINEERING INVESTIGATIONS AT THE MONTANA STATION, Montana Sta. (Bozeman) Bien. Rpt. 1939-40, pp. 36, 37. Work on the following subjects is briefly reported upon by O. W. Monson: Home-made water-lifting devices and water-power utilization, water-supply studies, range improvement through water conservation, return flow and duty of water investigations, and rural electrification studies.

Literature Received

THE FEDERAL LABOR LAWS, by Russell L. Greenman and Leslie L. Sanders. Cloth bound, 72 pages, 5½x8 in. This is a combination in one binding of separate digests of the Wagner Act, the Wages and Hours Act, and the Walsh-Healey Act. It explains particularly provisions of these acts influencing department heads, foremen, and other supervisory personnel, as to their relations with labor, records required, and other precautions necessary to enable employers to comply with the letter, as well as the spirit, of these laws. The National Foremen's Institute, Deep River, Conn. $1.50.

PRACTICAL ELECTRICAL WIRING, by H. P. Richter. Second edition. Cloth bound, X + 521 pages, 5½x8 in. Three parts, 33 chapters, appendix, bibliography, and index. This guide to wiring practice, calculated to be simple enough for the beginner but thorough enough to be a useful reference for experienced wiring technicians, aims to show both the way wiring operations are performed and why they are done in the ways indicated. In this edition no material has been eliminated, some new material has been added, and it all has been checked and revised as necessary to reconcile the data and practices with the requirements of the 1940 National Electrical Code. Parts cover theory and basic principles, actual wiring of residences and farms, and actual wiring of nonresidential projects. McGraw-Hill Book Co. (New York) $3.00.

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Activities in Fire Prevention and Protection

(Continued from page 230)

interested in the work of the Farm Fire Protection Committee. The work of this committee is thus described by the Association:

"This committee covers the various phases of the problem of loss of life and property by fire on farms and in rural communities. The committee prepares standards on subjects in this field, and adapts and simplifies for farm and rural application, the general standards of the Association. . . . This committee functions in both a technical and educational capacity, in active cooperation with the U. S. Department of Agriculture."

The comprehensive nature of the work of the Association may be more fully appreciated by considering the activities of the Farm Fire Protection Committee, which may be shown briefly by listing the titles of the subcommittees as follows: (1) Farm fire losses, (2) construction and location of farm buildings, (3) lightning protection, (4) electrical installations on farms, (5) first aid fire appliances, (6) water systems for fire protection on farms, (7) rural (community) fire protection, (8) handling and storage of gasoline and kerosene, and (9) arson (joint with National Fire Waste Council).

The National Fire Waste Council which is affiliated with the Insurance Department of the Chamber of Commerce of the United States, was organized to assist and cooperate with chambers of commerce and trade associations in fire prevention activities. The work of this group supplements that of the National Fire Protection Association, and comprises largely publicity and education. Headquarters of this organization are maintained at the offices of the Chamber of Commerce of the United States in Washington, D. C. The Committee activities are broad and comprehensive. Contacts are maintained with a large number of organizations, divided roughly into six groups:

1 Public information—daily and weekly newspapers, farm journals, radio, demonstrations, fire prevention week, and publications.

2 Rural youth—4-H Clubs, Rural Scouts, and Future Farmers.

3 Trade Associations—Agricultural equipment manufacturers, mutual fire insurance, a national association of local agents, special agents, and stock fire insurance.

4 Fire control—Motorized equipment manufacturers, agricultural engineers, rural fire departments and water supplies, first aid protective appliance manufacturers, lightning rod manufacturers, spark arrester manufacturers, Rural Electrification Administration, rural telephone associations, and public utilities.

5 Education—Red Cross, Farm Credit Administration, agricultural colleges, and fire marshals.

6 Agricultural organizations—Farm Bureau, Grange, and Farmers' Union.

The people of northern Europe have demonstrated the possibility of keeping the per capita fire waste low. Immigrants from there appear to be equally careful and to experience relatively few fires in this country. Studies of fire waste in this country indicate that they result largely from preventible causes.

Interest alone, although essential, will not prevent fires. We must have facts and then utilize them in a systematic approach. The agricultural engineer occupies a strategic position with reference to fire prevention on farms and the rural areas. May we make the most of it.